# Activity Report 2017

# Section Partnerships and Cooperations

<span style="color:red">CAMUS Team</span>

# 9. Partnerships and Cooperations

## 9.1. National Initiatives

### 9.1.1. *Inria Large Scale Initiative on Multicore*

Philippe Clauss, Jens Gustedt, Alain Ketterlin, Cédric Bastoul and Vincent Loechner are involved in the Inria Project Lab entitled "Large scale multicore virtualization for performance scaling and portability" and regrouping several French researchers in compilers, parallel computing and program optimization [0]. The project started officially in January 2013. In this context and since January 2013, Philippe Clauss is co-advising with Erven Rohou of the Inria team PACAP, Nabil Hallou's PhD thesis focusing on dynamic optimization of binary code. The PhD defense was held December the 18th 2017.

Philippe Clauss, Jens Gustedt and Maxime Mogé are involved in the ADT Inria project ASNAP (*Accélération des Simulations Numériques pour l'Assistance Peropératoire*), in collaboration with the Inria team MIMESIS. The goal is to find opportunities in the SOFA simulation platform for applying automatic parallelization techniques developed by Camus. We are currently investigating two approaches. The first uses memory behavior memoization to generate a parallel code made of independent threads at runtime. The second uses ordered read-write locks (ORWL) to dynamically schedule a pipeline of parallel tasks.

### 9.1.2. *ANR AJACS*

**Participant:** Arthur Charguéraud [contact].

The AJACS research project is funded by the programme "Société de l'information et de la communication" of the ANR, from October 2014, until November 2018. <span style="color:red">http://ajacs.inria.fr/</span>

The goal of the AJACS project is to provide strong security and privacy guarantees on the client side for web application scripts implemented in JavaScript, the most widely used language for the Web. The proposal is to prove correct analyses for JavaScript programs, in particular information flow analyses that guarantee no secret information is leaked to malicious parties. The definition of sub-languages of JavaScript, with certified compilation techniques targeting them, will allow deriving more precise analyses. Another aspect of the proposal is the design and certification of security and privacy enforcement mechanisms for web applications, including the APIs used to program real-world applications. Arthur Charguéraud focuses on the description of a formal semantics for JavaScript, and the development of tools for interactively executing programs step-by-step according to the formal semantics.

Partners: team Celtique (Inria Rennes - Bretagne Atlantique), team Prosecco (Inria Paris), team Indes (Inria Sophia Antipolis - Méditerranée), and Imperial College (London).

### 9.1.3. *ANR Vocal*

**Participant:** Arthur Charguéraud [contact].

The Vocal research project is funded by the programme "Société de l'information et de la communication" of the ANR, for a period of 48 months, starting on October 1st, 2015. <span style="color:red">https://vocal.lri.fr/</span>

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[0]<span style="color:red">https://team.inria.fr/multicore</span>

The goal of the Vocal project is to develop the first formally verified library of efficient general-purpose data structures and algorithms. It targets the OCaml programming language, which allows for fairly efficient code and offers a simple programming model that eases reasoning about programs. The library will be readily available to implementers of safety-critical OCaml programs, such as Coq, Astrée, or Frama-C. It will provide the essential building blocks needed to significantly decrease the cost of developing safe software. The project intends to combine the strengths of three verification tools, namely Coq, Why3, and CFML. It will use Coq to obtain a common mathematical foundation for program specifications, as well as to verify purely functional components. It will use Why3 to verify a broad range of imperative programs with a high degree of proof automation. Finally, it will use CFML for formal reasoning about effectful higher-order functions and data structures making use of pointers and sharing.

Partners: team Gallium (Inria Paris), team DCS (Verimag), TrustInSoft, and OCamlPro.

# 9.2. European Initiatives

## 9.2.1. FP7 & H2020 Projects

Project acronym: ERC Deepsea

Project title: Parallel dynamic computations

Duration: Jun. 2013 - May 2018

Coordinator: Umut A. Acar

Other partners: Carnegie Mellon University

Abstract:

The objective of this project is to develop abstractions, algorithms and languages for parallelism and dynamic parallelism with applications to problems on large data sets. Umut A. Acar (affiliated to Carnegie Mellon University and Inria Paris - Rocquencourt) is the principal investigator of this ERC-funded project. The other main researchers involved are Mike Rainey (Inria, Gallium team), who is full-time on the project, and Arthur Charguéraud (Inria, Toccata Camus), who works part time on this project. Project website: http://deepsea.inria.fr/.

# 9.3. International Initiatives

## 9.3.1. Inria International Partners

### 9.3.1.1. Informal International Partners

The CAMUS team maintains regular contacts with the following entities:

- Reservoir Labs, New York, NY, USA
- University of Batna, Algeria
- Ohio State University, Colombus, USA
- Louisiana State University, Baton Rouge, USA
- Colorado State University, Fort Collins, USA
- Carnegie Mellon University, Pittsburgh, USA
- Indian Institute of Science (IIIS) Bangalore, India
- Barcelona Supercomputing Center, Barcelona, Spain

<p style="text-align:center;"><span style="color:red">**CARAMBA Project-Team**</span></p>

# 9. Partnerships and Cooperations

## 9.1. National Initiatives

### 9.1.1. PEPS CHARIoT

The PEPS CHARIoT ("CHiffrement Authentifié pour Renforcer l'IoT") project is dedicated to the study of authenticated encryption schemes, especially the CAESAR candidates, and to the performance analysis of those schemes on dedicated embedded architectures such as micro-controllers (MSP430, ARM and AVR). It involves Marine Minier (CARAMBA), Franck Rousseau (IMAG - Grenoble) and Pascal Lafourcade (LIMOS-UCA - Clermont-Ferrand).

## 9.2. International Research Visitors

### 9.2.1. Visits of International Scientists

Thorsten Kleinjung from EPFL visited the team from 6 to 10 February to work on the Number Field Sieve algorithm.

<p style="text-align:center; color:red;">**CARTE Team**</p>

# 9. Partnerships and Cooperations

## 9.1. National Initiatives

### 9.1.1. ANR

- Simon Perdrix is PI of the PRCE ANR SoftQPro "Solutions logicielles pour l'optimisation des programmes et ressources quantiques". (2017- 2021) [Atos-Bull, LORIA, CEA, LRI].

- The team is partner of the ANR VanQuTe "Validation des technologies quantiques émergentes" (PRCI with Singapore) [LIP6, LORIA, SUTD, NUS, NTU] (2018-2022)

- The team is a partner in ANR Elica (2014-2019), "Elargir les idées logistiques pour l'analyse de complexité". The CARTE team is well known for its expertise in implicit computational complexity.

## 9.2. European Initiatives

### 9.2.1. FP7 & H2020 Projects

Mathieu Hoyrup participates in the Marie-Curie RISE project Computing with Infinite Data coordinated by Dieter Spreen (Univ. Siegen) that has started in April 2017. We organized a workshop CCC'17 in Nancy in June 2017, that was also the first meeting of the project.

### 9.2.2. Collaborations in European Programs, Except FP7 & H2020

The team is partner of the ITEA3 Quantex project [LORIA, LRI, CEA/Leti, Atos-Bull, Siemens, TUDelft, KPN, EKUT] (2018-2020)

## 9.3. International Initiatives

Simon Perdrix is member of the STIC AmSud FoQCOSS with Argentina. He visited Quilmes University during 2 weeks in July 2017.

## 9.4. International Research Visitors

### 9.4.1. Visits of International Scientists

Ross Duncan (Assistant Prof. at Strathclyde U., Glasgow), spent one month (June 2017) in our team as an invited professor at Université de Lorraine.

### 9.4.2. Internships

Jordina Francès de Mas, Quentin Ladeveze were interns in our team ; they worked on cellular automata and produced two technical reports (see [34] and [38]).

<p style="text-align:center"><span style="color:red">**GAMBLE Project-Team**</span></p>

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

We organized, with colleagues of the mathematics department (Institut Elie Cartan Nancy) a regular working group about geometry and probability.

## 9.2. National Initiatives

### 9.2.1. ANR SingCAST

The objective of the young-researcher ANR grant SingCAST is to intertwine further symbolic/numeric approaches to compute efficiently solution sets of polynomial systems with topological and geometrical guarantees in singular cases. We focus on two applications: the visualization of algebraic curves and surfaces and the mechanical design of robots.

After identifying classes of problems with restricted types of singularities, we plan to develop dedicated symbolic-numerical methods that take advantage of the structure of the associated polynomial systems that cannot be handled by purely symbolic or numerical methods. Thus we plan to extend the class of manipulators that can be analyzed, and the class of algebraic curves and surfaces that can be visualized with certification.

The project has a total budget of 100kE. It started on March 1st 2014 and will finished in August 2018. It is coordinated by Guillaume Moroz, with a participation of 60%, and Marc Pouget with a participation of 40%.

Project website: <span style="color:red">https://project.inria.fr/singcast/</span>.

## 9.3. International Initiatives

### 9.3.1. Inria Associate Teams Not Involved in an Inria International Lab

#### 9.3.1.1. Astonishing

> Title: ASsociate Team On Non-ISH euclIdeaN Geometry
>
> International Partners (Institution - Laboratory - Researcher):
>
> > University of Groningen (Netherlands) - Johann Bernouilli Institute of Mathematics and Computer Science - Gert Vegter
> >
> > University of Luxembourg - Mathematics Research Unit - Jean-Marc Schlenker
> >
> > Université Paris Est Marne-la-Vallée - Laboratoire d'Informatique Gaspard Monge - Éric Colin de Verdière
>
> Start year: 2017
>
> See also: <span style="color:red">https://members.loria.fr/Monique.Teillaud/collab/Astonishing/</span>
>
> Some research directions in computational geometry have hardly been explored. The spaces in which most algorithms have been designed are the Euclidean spaces $R^d$. To extend further the scope of applicability of computational geometry, other spaces must be considered, as shown by the concrete needs expressed by our contacts in various fields as well as in the literature. Delaunay triangulations in non-Euclidean spaces are required, e.g., in geometric modeling, neuromathematics, or physics. Topological problems for curves and graphs on surfaces arise in various applications in computer graphics and road map design. Providing robust implementations of these results is a key towards their reusability in more applied fields. We aim at studying various structures and algorithms in other spaces than $R^d$, from a computational geometry viewpoint. Proposing algorithms operating in such spaces requires a prior deep study of the mathematical properties of the objects considered, which raises new fundamental and difficult questions that we want to tackle.

## 9.4. International Research Visitors

### 9.4.1. Visits of International Scientists

Gert Vegter spent three weeks in GAMBLE in the framework of the Astonishing associate team.

### 9.4.2. Visits to International Teams

Olivier Devillers spent one month at Computational Geometry Lab of Carleton University http://cglab.ca/about.html.

<p align="center" style="color:red"><strong>PESTO Project-Team</strong></p>

# 9. Partnerships and Cooperations

## 9.1. National Initiatives

### 9.1.1. CNRS

- CNRS PEPS INS2I 2016-2018 project ASSI *Analyse de Sécurité de Systèmes Industriels*, duration: 2 years, leader: Pascal Lafourcade (Univ Clermont-Ferrand), participant Pesto: Jannik Dreier, other participants: Marie-Laure Potet, Maxime Puys (Univ Grenoble-Alpes).

  The goal of the project is to develop an approach to verify protocols used in industrial control (SCADA) systems using tools such as *TAMARIN* or ProVerif. These protocols have specific security requirements such as flow integrity, going beyond the classical authentication and secrecy properties. The project also aims at analyzing different intruder models matching the particularities of industrial systems, and to develop specific modeling and verification techniques.

### 9.1.2. ANR

- ANR SEQUOIA *Security properties, process equivalences and automated verification*, duration: 4 years, since October 2014, leader: Steve Kremer, other partners: ENS Cachan, Univ Luxembourg. Most protocol analysis tools are restricted to analyzing reachability properties while many security properties need to be expressed in terms of some process equivalences. The increasing use of observational equivalence as a modeling tool shows the need for new tools and techniques that are able to analyze such equivalence properties. The aims of this project are *(i)* to investigate which process equivalences – among the plethora of existing ones – are appropriate for a given security property, system assumptions and attacker capabilities; *(ii)* to advance the state-of-the-art of automated verification for process equivalences, allowing for instance support for more cryptographic primitives, relevant for case studies; *(iii)* to study protocols that use low-entropy secrets expressed using process equivalences; *(iv)* to apply these results to case studies from electronic voting.

- ANR TECAP *Protocol Analysis — Combining Existing Tools*, duration: 4 years, starting in 2018, leader: Vincent Cheval, other partners: ENS Cachan, Inria Paris, Inria Sophia Antipolis, IRISA, LIX. Despite the large number of automated verification tools, several cryptographic protocols (e.g. stateful protocols) still represent a real challenge for these tools and reveal their limitations. To cope with these limits, each tool focuses on different classes of protocols depending on the primitives, the security properties, etc. Moreover, the tools cannot interact with each other as they evolve in their own model with specific assumptions. The aim of this project is to get the best of all these tools, meaning, to improve the theory and implementations of each individual tool towards the strengths of the others and, to build bridges that allow the cooperations of the methods/tools. We will focus in this project on the tools CryptoVerif, EasyCrypt, Scary, ProVerif, *TAMARIN*, *Akiss* and APTE. In order to validate the results obtained in this project, we will apply our results to several case studies such as the Authentication and Key Agreement protocol from the telecommunication networks, the Scytl and Helios voting protocols, and the low entropy authentication protocols 3D-Secure. These protocols have been chosen to cover many challenges that the current tools are facing.

### 9.1.3. Fondation MAIF

Project *Protection de l'information personnelle sur les réseaux sociaux*, duration: 3 years, started in October 2014. The goal of the project is to lay the foundation for a risk verification environment on privacy in social networks. Given social relations, this environment will rely on the study of metrics to characterize the security level for a user. Next, by combining symbolic and statistical techniques, an objective is to synthesize a model of risk behavior as a rule base. Finally, a verifier based on model-checking will be developed to assess the security level of user. Partners are Pesto (leader), Orpailleur and Fondation MAIF.

## 9.2. European Initiatives

### 9.2.1. FP7 & H2020 Projects

- SPOOC (2015–2020) [0]— ERC Consolidator Grant on Automated Security Proofs of Cryptographic Protocols: Privacy, Untrusted Platforms and Applications to E-voting Protocols.

  The goals of the Spooc project are to develop solid foundations and practical tools to analyze and formally prove security properties that ensure the privacy of users as well as techniques for executing protocols on untrusted platforms. We will

  – develop foundations and practical tools for specifying and formally verifying new security properties, in particular privacy properties;

  – develop techniques for the design and automated analysis of protocols that have to be executed on untrusted platforms;

  – apply these methods in particular to novel e-voting protocols, which aim at guaranteeing strong security guarantees without need to trust the voter client software.

  Steve Kremer is the leader of the project.

## 9.3. International Initiatives

### 9.3.1. Inria International Partners

- Collaboration with David Basin, Ralf Sasse and Lara Schmid (ETH Zurich), Cas Cremers (Univ Oxford), and Sasa Radomirovic (Univ Dundee) on the improvement of the *TAMARIN* prover
- Collaboration with Bogdan Warinschi (Univ Bristol) on defining game-based privacy for e-voting protocols and isolated execution environments
- Collaboration with Myrto Arapinis (Univ Edinburgh) on simplification results for the formal analysis of e-voting protocols
- Collaboration with Matteo Maffei (CISPA, Germany) on type systems for e-voting systems
- Collaboration with Michael Backes and Robert Künnemann (CISPA, Germany) on automated verification of security protocols
- Collaboration with Paliath Narendran's group (SUNY Albany) on automated deduction
- Collaboration with Hanifa Boucheneb's group (Polytechnique Montreal) on model-checking of collaborative systems
- Collaboration with John Mullins's group (Polytechnique Montreal) on information hiding

## 9.4. International Research Visitors

### 9.4.1. Visits of International Scientists

- David Galindo (Univ Birmingham), June 2017
- Bogdan Warinschi (Univ Bristol), November 2017

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[0] https://members.loria.fr/SKremer/files/spooc/index.html

# VERIDIS Project-Team

# 9. Partnerships and Cooperations

## 9.1. National Initiatives

### 9.1.1. ANR-DFG Project SMArT

**Participants:**  Haniel Barbosa, Pascal Fontaine, Stephan Merz, Thomas Sturm.

*The SMArT (Satisfiability Modulo Arithmetic Theories) project was funded by ANR-DFG Programmes blancs 2013, a bilateral (French-German) program of Agence Nationale de la Recherche and Deutsche Forschungsgemeinschaft DFG. It started in April 2014 and finished in September 2017. The project gathered members of VeriDis in Nancy and Saarbrücken, and the Systerel company.*

The objective of the SMArT project was to provide advanced techniques for arithmetic reasoning beyond linear arithmetic for formal system verification, and particularly for SMT. The results feed back into the implementations of Redlog and veriT, which also serve as experimentation platforms for theories, techniques and methods designed within this project.

More information on the project can be found on http://smart.gforge.inria.fr/.

### 9.1.2. ANR Project IMPEX

**Participants:**  Souad Kherroubi, Dominique Méry.

*The ANR Project IMPEX, within the INS program, started in December 2013 for 4 years. It was coordinated by Dominique Méry, the other partners are IRIT/ENSEIHT, Systerel, Supelec, and Telecom Sud Paris. The work reported here also included a cooperation with Pierre Castéran from LaBRI Bordeaux.*

Modeling languages provide techniques and tool support for the design, synthesis, and analysis of the models resulting from a given modeling activity, as part of a system development process. These languages quite successfully focus on the analysis of the designed system, exploiting the semantic power of the underlying modeling language. The semantics of this modeling languages are well understood by its users (in particular the system designers), i.e. the semantics is implicit in the model. In general, modeling languages are not equipped with resources, concepts or entities handling explicitly domain engineering features and characteristics (domain knowledge) underlying the modeled systems. Indeed, the designer has to explicitly handle the knowledge resulting from an analysis of this application domain [61], i.e. explicit semantics. At present, making explicit the domain knowledge inside system design models does not obey any methodological rules validated by practice. The users of modeling languages introduce these domain knowledge features through types, constraints, profiles, etc. Our claim is that ontologies are good candidates for handling explicit domain knowledge. They define domain theories and provide resources for uniquely identifying domain knowledge concepts. Therefore, allowing models to make references to ontologies is a modular solution for models to explicitly handle domain knowledge. Overcoming the absence of explicit semantics expression in the modeling languages used to specify systems models will increase the robustness of the designed system models. Indeed, the axioms and theorems resulting from the ontologies can be used to strengthen the properties of the designed models. The objective [50] is to offer rigorous mechanisms for handling domain knowledge in design models.

### 9.1.3. ANR Project Formedicis

**Participant:**  Dominique Méry.

*The ANR Project Formedicis, within the INS program, started in January 2017 for 4 years. It is coordinated by Bruno d'Augsbourg, the partners are ONERA, IRIT/ENSEIHT, ENAC, and LORIA.*

During the last 30 years, the aerospace domain has successfully devised rigorous methods and tools for the development of safe functionally-correct software. During this process, interactive software has received a relatively lower amount of attention. However, Human-System Interactions (HSI) are important for critical systems and especially in aeronautics: new generations of aircraft cockpits make use of sophisticated electronic devices that may be driven by more and more complex software applications. The criticality of these applications require a high degree of assurance for their intended behavior. The report by the French *Bureau d'Enquêtes et d'Analyses* about the crash of the Rio-Paris flight AF 447 in 2009 pointed out a design issue in the behavior of the Flight Director interface as one of the original causes of the crash.

We believe that part of these issues are due to the lack of a well-defined domain specific "hub" language to represent interactive software design in a way that allows system designers to iterate on their designs before injecting them in a development process, and system developers to verify their software against the chosen design. Formedicis aims at designing such a formal hub language $L$, in which designers can express their requirements concerning the interactive behavior that must be embedded inside the interactive applications. The project will also develop a framework for validating, verifying, and implementing critical interactive applications designed and denoted in $L$.

More information on the project is available at http://www.agence-nationale-recherche.fr/Project-ANR-16-CE25-0007.

### 9.1.4. ANR Project PARDI

**Participants:** Marie Duflot-Kremer, Stephan Merz.

*PARDI (Verification of parameterized distributed systems) is funded by ANR. The project started in January 2017 for a duration of 48 months. The project partners other than VeriDis are Toulouse INP (coordinator), Université Paris Sud, and Université Paris Marie Curie.*

Distributed systems and algorithms are parameterized by the number of participating processes, the communication model, the fault model, and more generally the properties of interaction among the processes. The project aims at providing methodological and tool support for verifying parameterized systems, using combinations of model checking and theorem proving. VeriDis contributes its expertise on TLA$^+$ and its verification tools, and the integration with the Cubicle model checker is a specific goal of the project.

More information on the project is available at http://pardi.enseeiht.fr/.

### 9.1.5. Inria IPL HAC SPECIS

**Participants:** Marie Duflot-Kremer, Stephan Merz.

The goal of the HAC SPECIS (High-performance Application and Computers: Studying PErformance and Correctness In Simulation) project is to answer methodological needs of HPC application and runtime developers and to allow studying real HPC systems with respect to both correctness and performance. To this end, this Inria Project Lab assembles experts from the HPC, formal verification, and performance evaluation communities.

HAC SPECIS started in 2016. VeriDis contributes through its expertise in formal verification techniques. In particular, our goal is to extend the functionalities of exhaustive and statistical model checking within the SimGrid platform.

### 9.1.6. Inria Technological Development Action CUIC

**Participants:** Jasmin Christian Blanchette, Simon Cruanes.

Most "theorems" initially given to a proof assistant are incorrect, whether because of a typo, a missing assumption, or a fundamental flaw. Novices and experts alike can enter invalid formulas and find themselves wasting hours, or even days, on an impossible proof. This project, funded by Inria and running from 2015 to 2017, supported the development of a counterexample generator for higher-order logic. This new tool, called Nunchaku, is intended for integration with various proof assistants. The project was coordinated by Jasmin Blanchette and also involved Inria Saclay – Île de France (Toccata group) and Inria Rennes – Bretagne

Atlantique (Celtique group), among others. Simon Cruanes worked on Nunchaku from October 2015 to September 2017, whereas Blanchette has developed an Isabelle frontend. Four releases have taken place so far, and the tool is an integral part of the Isabelle2017 official release. Work has started on Coq and TLAPS frontends, and we will soon work on a Lean frontend as well. The tool is described in [62] and was presented at a workshop last year [57]. A noteworthy development this year is the creation of a backend called SMBC, based on new ideas by Cruanes about how to combine SAT solving and narrowing [29].

## 9.2. European Initiatives

### 9.2.1. FP7 & H2020 Projects

#### 9.2.1.1. ERC Matryoshka

Program: European Union's Horizon 2020 research and innovation program

Project acronym: Matryoshka

Duration: April 2017 – March 2022

Coordinator: Jasmin Blanchette (VU Amsterdam)

Proof assistants are increasingly used to verify hardware and software and to formalize mathematics. However, despite the success stories, they remain very laborious to use. The situation has improved with the integration of first-order automatic theorem provers—superposition provers and SMT (satisfiability modulo theories) solvers—through middleware such as Sledgehammer for Isabelle/HOL and HOLyHammer for HOL Light and HOL4; but this research has now reached the point of diminishing returns. Only so much can be done when viewing automatic provers as black boxes.

To make interactive verification more cost-effective, we propose to deliver very high levels of automation to users of proof assistants by fusing and extending two lines of research: automatic and interactive theorem proving. This is our grand challenge. Our starting point is that first-order (FO) automatic provers are the best tools available for performing most of the logical work. Our approach will be to enrich superposition and SMT with higher-order (HO) reasoning in a careful manner, in order to preserve their desirable properties. We will design proof rules and strategies, guided by representative benchmarks from interactive verification.

With higher-order superposition and higher-order SMT in place, we will develop highly automatic provers building on modern superposition provers and SMT solvers, following a novel stratified architecture. To reach end users, these new provers will be integrated in proof assistants and will be available as backends to more specialized verification tools. The users of proof assistants and similar tools stand to experience substantial productivity gains: From 2010 to 2016, the success rate of automatic provers on interactive proof obligations from a representative benchmark suite called Judgment Day has risen from 47% to 77%; with this project, we aim at 90%–95% proof automation.

The Matryoshka ERC grant of Jasmin Blanchette includes Pascal Fontaine and Uwe Waldmann as senior researchers.

#### 9.2.1.2. FET-Open CSA SC$^2$

Program: European Union's Horizon 2020 research and innovation program

Project acronym: SC$^2$

Project title: Symbolic Computation and Satisfiability Checking

Duration: July 2016 – August 2018

Coordinator: James Davenport (U. of Bath, UK)

Other partners: see http://www.sc-square.org/CSA/welcome.html

The use of advanced methods for solving practical and industrially relevant problems by computers has a long history. Whereas Symbolic Computation is concerned with the algorithmic determination of exact solutions to complex mathematical problems, more recent developments in the area of Satisfiability Checking tackle similar problems but with different algorithmic and technological solutions.

Though both communities have made remarkable progress in the last decades, they still need to be strengthened to tackle practical problems of rapidly increasing size and complexity. Their separate tools (computer algebra systems and SMT solvers) are urgently needed to examine prevailing problems with a direct effect to our society. For example, Satisfiability Checking is an essential backend for assuring the security and the safety of computer systems. In various scientific areas, Symbolic Computation enables dealing with large mathematical problems out of reach of pencil and paper developments.

Currently the two communities are largely disjoint and unaware of the achievements of each other, despite strong reasons for them to discuss and collaborate, as they share many central interests. However, researchers from these two communities rarely interact, and also their tools lack common, mutual interfaces for unifying their strengths. Bridges between the communities in the form of common platforms and roadmaps are necessary to initiate an exchange, and to support and to direct their interaction. These are the main objectives of this CSA. We initiate a wide range of activities to bring the two communities together, identify common challenges, offer global events and bilateral visits, propose standards, and so on.

We believe that these activities will foster cross-fertilisation of both fields and bring mutual improvements. Combining the knowledge, experience and the technologies in these communities will enable the development of radically improved software tools.

This project is locally coordinated by Pascal Fontaine.

# 9.3. International Initiatives

## 9.3.1. Inria International Partners

Title: Kanazawa-Nancy for Satistifiability and Arithmetics (KANASA)

International Partner: Japan Advanced Institute for Science and Technology (Dept. Intelligent Robotics, Mizuhito Ogawa)

Starting year: 2016

During the last decade, there has been tremendous progress on symbolic verification techniques, spurred in particular by the development of SMT (satisfiability modulo theories) techniques and tools. Our first direction of research will be to investigate the theoretical background and the practical techniques to integrate Interval Constraint Propagation within a generic SMT framework, including other decision procedures and quantifier handling techniques. On the purely arithmetic side, we also want to study how to unite the reasoning power of all arithmetic techniques developed in the team, including simplex-based SMT-like reasoners, Virtual Substitution, and Cylindrical Algebraic Decomposition. In particular, this includes developing theory combination frameworks for linear and non-linear arithmetic. There is a strong incentive for these kind of combinations since even non-linear SMT problems contain a large proportion of linear constraints. The partnership is supported by a Memorandum of Understanding between JAIST and LORIA.

One PhD student from JAIST spent one year in the VeriDiS team, until May 2017. The partnership evolves towards applying SMT to find malware in obfuscated code.

# 9.4. International Research Visitors

## 9.4.1. Visits of International Scientists

Tung Vu Xuan

> Date: 1 May 2016 – 30 April 2017
>
> Institution: JAIST
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> Host: Pascal Fontaine

Tung Vu Xuan is a PhD student at JAIST, Japan. He was visiting VeriDis in the context of the KANASA project. He works mainly on Interval Constraint Propagation (ICP), a heuristic but powerful method for satisfiability checking of non-linear arithmetic (NLA) constraints. During his stay, we investigated techniques to combine ICP with decision procedures for NLA within an SMT context, and adapted the subtropical method from computer algebra to the context of SMT. This work is relevant for the SMArT and SC$^2$ projects.

Andrew J. Reynolds

> Date: 16 July 2017 – 17 September 2017
>
> Institution: The University of Iowa
>
> Host: Pascal Fontaine

Andrew J. Reynolds is a Research Scientist at the University of Iowa and one of main developers of the award-winning Satisfiability Modulo Theories (SMT) solver CVC4. His current research interests include implementing techniques in SMT solvers for unbounded strings and regular expressions, first-order quantified formulas and synthesis conjectures. He was an Inria invited researcher for two months in Nancy. We continued working on quantifier handling for SMT, along the lines of [20], and studied enumerative instantiation. This work contributes to the Matryoshka, SMArT and SC$^2$ projects.

### 9.4.2. Internships

Poonam Kumari

> Date: 1 March – 31 July
>
> Institution: Université de Lorraine (Erasmus Mundus DESEM)
>
> Host: Stephan Merz

Poonam Kumari worked on a translation from a restricted subset of TLA$^+$ specifications into the input language of the Cubicle model checker for array-based parameterized systems.

<span style="color:red">**SPHINX Project-Team**</span>

# 9. Partnerships and Cooperations

## 9.1. National Initiatives

### 9.1.1. ANR

- **Project Acronym :** iproblems
  **Project Title :** Inverse Problems
  **Coordinator :** David Dos Santos Ferreira
  **Duration :** 48 months (2013-2017)
  **Partner:** Institut Élie Cartan de Lorraine
  **URL:** http://www.agence-nationale-recherche.fr/Projet-ANR-13-JS01-0006

- **Project Acronym :** IFSMACS
  **Project Title :** Fluid-Structure Interaction: Modeling, Analysis, Control and Simulation
  **Coordinator:** Takéo Takahashi
  **Participants:** Julien Lequeurre, Alexandre Munnier, Jean-François Scheid, Takéo Takahashi
  **Duration :** 48 months (starting on October 1st, 2016)
  **Other partners:** Institut de Mathématiques de Bordeaux, Inria Paris, Institut de Mathématiques de Toulouse
  **Abstract:** The aim of this project is to analyze systems composed by structures immersed in a fluid. Studies of such systems can be motivated by many applications (motion of the blood in veins, fish locomotion, design of submarines, etc.) but also by the corresponding challenging mathematical problems. Among the important difficulties inherent to these systems, one can quote nonlinearity, coupling, free-boundaries. Our objectives include asymptotic analyses of FSIS, the study of controllability and stabilizability of FSIS, the understanding of locomotion of self-propelled structures and the analyze and development of numerical tools to simulate fluid-structure system.
  **URL:** http://ifsmacs.iecl.univ-lorraine.fr/

- Xavier Antoine is member of the project TECSER funded by the French armament procurement agency in the framework of the Specific Support for Research Works and Innovation Defense (ASTRID 2013 program) operated by the French National Research Agency.
  **Project Acronym:** TECSER
  **Project Title :** Nouvelles techniques de résolution adaptées à la simulation haute performance pour le calcul SER
  **Coordinator:** Stéphane Lanteri (Inria, NACHOS project-team)
  **Duration:** 36 months (starting on May 1st, 2014)
  **Other partners:** EADS (France Innovation Works Dep.), NUCLETUDES
  **URL:** http://www-sop.inria.fr/nachos/projects/tecser/index.php/Main/HomePage

- **Project Acronym:** BoND
  **Project Title:** Boundaries, Numerics and Dispersion.
  **Coordinator:** Sylvie Benzoni (Institut Camille Jordan, Lyon, France)
  **Participant:** Xavier Antoine
  **Duration:** 48 months (starting on October 15th, 2013)
  **URL:** http://bond.math.cnrs.fr

- Xavier Antoine is the local coordinator of the ANR project BECASIM.
  **Project acronym:** BECASIM
  **Project Title:** Bose-Einstein Condensates: Advanced SIMulation Deterministic and Stochastic Computational Models, HPC Implementation, Simulation of Experiments.
  **Coordinator:** Ionut Danaila (Université de Rouen, France)
  **Participant:** Xavier antoine
  **Duration:** 48 months (plus an extension of 12 months, until November 2017)
  **Other partners:** Laboratoire de Mathématiques Raphaël Salem, (Université de Rouen); Laboratoire Jacques-Louis Lions (Université Pierre et Marie Curie); Centre de Mathématiques Appliquées (Ecole Polytechnique); Centre d'Enseignement et de Recherche en Mathématiques et Calcul Scientifique (École des Ponts ParisTech); Loria; Laboratoire Paul Painlevé (Université Lille 1) et Inria-Lille Nord-Europe; Institut de Mathématiques et de Modélisation de Montpellier (Université Montpellier 2)
  **URL:** http://becasim.math.cnrs.fr

- **Project Acronym:** QUACO
  **Project title:** use of geometrical tools for the control of quantum system and application to MRI.
  **Coordinator:** Thomas Chambrion
  **Duration:** 48 months (starting January 1st 2018).

- **Project acronym:** ISDEEC
  **Project title:** Interaction entre Systèmes Dynamiques, Equations d'Evolution et Contrôle
  **Coordinator:** Romain Joly
  **Participant:** Julie Valein
  **Other partners:** Institut Fourier, Grenoble; Département de Mathématiques d'Orsay
  **Duration:** 36 months (2017-2020)
  **URL:** http://isdeec.math.cnrs.fr/

### 9.1.2. CNRS

Thomas Chambrion is the coordinator of the Research Project from CNRS Inphynity "DISQUO" (5300 euros, 2017).

## 9.2. International Initiatives

### 9.2.1. Participation in Other International Programs

D. Dos Santos Ferreira and J.-F. Scheid are members of the PHC Utique program ...

Program: PHC Utique

Project title: Équations aux Dérivées Partielles Déterministes et Stochastiques

Duration: January 2017-January 2020

Other partners: Laboratoire de Modélisation De´terministe et Ale´atoire (LAMDA), École Supérieure des Sciences et de la Technologie de Hammam Sousse (ESSTHS), Université de Sousse, Tunisie.

Abstract: The main objective of this project is to study some systems of Ordinary Differential Equations (ODE) and Partial Differential Equations (PDE) in a deterministic and stochastic frameworks with analytical, numerical, probabilistic or statistical methods. A typical system considered in this project is the modeling and the numerical simulations of the myocardial infarction (heart attack). This phenomenon is studied as a fluid/structure interaction type process between the blood, the cholesterol deposit along the walls of an artery and the rupture of the atherosclerotic plaque formed by the cholesterol.

This is a project for a French-Tunisian collaboration and it involved a PhD thesis co-advised by J.-F. Scheid.

J. Valein is member of the project ICoPS:

Program: MATH-AmSud

Project acronym: ICoPS

Project title: Inverse and control problems for physical systems

Duration: 01/2017-12/2018

Coordinators: Alberto Mercado (Valparaíso, Chile), Emmanuelle Crépeau (Versailles), Daniel Alfaro (Rio de Janeiro, Brasil), Ivonne Rivas (Colombia)

Other partners: Centre Automatique et Systèmes (École des Mines de Paris), LAAS (Toulouse), Instituto de Matemática, Estadística e Física (Universidade Federal do Rio Grande do Sul, Brasil), Departamento de Matemáticas y Estadística, (Universidad Icesi, Pance, Cali, Colombia)

Abstract: We propose to study well-posedness, control properties, and coefficient inverse problems for partial differential equations appearing in models for several phenomena. We intend to study the inverse problems of recovering some coefficients in the previously mentioned equations, and also in nonlinear dispersive waves on trees, which appears for instance in model for the cardiovascular system. We intend to study numerical approximations, using numerical schemes like Galerkin, colocation, finite difference, among others. Finally, this proposal includes the determination of the reachable states in a control problem of KdV equation.

## 9.3. International Research Visitors

J.-F. Scheid has been visitor of the l'ESSTHS (Hammam-Sousse, Tunisia) for two weeks (work related to the thesis of Imen JBILI) and course on numerical methods for the Navier-Stokes equations).

### 9.3.1. *Visits of International Scientists*

Sorin Micu (University of Craiova) was an invited professor (University of Lorraine) from 12/01/2017 to 12/02/2017.

<span style="color:red">**TOSCA Project-Team**</span>

# 9. Partnerships and Cooperations

## 9.1. National Initiatives

### 9.1.1. ANR

N. Champagnat is member of the ANR NONLOCAL (Phénomènes de propagation et équations non locales, 2014–2018) coordinated by F. Hamel (Univ. Aix-Marseille).

### 9.1.2. ITMO project

N. Champagnat, C. Fritsch and D. Villemonais are involved in an ITMO Cancer project (INSERM funding) on "Modeling ctDNA dynamics for detecting targeted therapy resistance" (2017-2020), involving researchers from IECL (Institut Elie Cartan de Lorraine), the Inria teams BIGS and TOSCA, ICL (Institut de Cancérologie de Lorraine), CRAN (Centre de Recherche en Automatique de Nancy) and CHRU Strasbourg (Centre Hospitalier Régional Universitaire). This project is coordinated by N. Champagnat.

## 9.2. European Initiatives

### 9.2.1. FP7 & H2020 Projects

Program: FP7

Project acronym: HBP

Project title: The Human Brain Project

Duration: April 2016 - March 2018 (second part)

Coordinator: EPFL

Other partners: see the webpage of the project.

Abstract: Understanding the human brain is one of the greatest challenges facing 21st century science. If we can rise to the challenge, we can gain profound insights into what makes us human, develop new treatments for brain diseases and build revolutionary new computing technologies. Today, for the first time, modern ICT has brought these goals within sight. The goal of the Human Brain Project, part of the FET Flagship Programme, is to translate this vision into reality, using ICT as a catalyst for a global collaborative effort to understand the human brain and its diseases and ultimately to emulate its computational capabilities. The Human Brain Project will last ten years and will consist of a ramp-up phase (from month 1 to month 36) and subsequent operational phases. This Grant Agreement covers the ramp-up phase. During this phase the strategic goals of the project will be to design, develop and deploy the first versions of six ICT platforms dedicated to Neuroinformatics, Brain Simulation, High Performance Computing, Medical Informatics, Neuromorphic Computing and Neurorobotics, and create a user community of research groups from within and outside the HBP, set up a European Institute for Theoretical Neuroscience, complete a set of pilot projects providing a first demonstration of the scientific value of the platforms and the Institute, develop the scientific and technological capabilities required by future versions of the platforms, implement a policy of Responsible Innovation, and a programme of transdisciplinary education, and develop a framework for collaboration that links the partners under strong scientific leadership and professional project management, providing a coherent European approach and ensuring effective alignment of regional, national and European research and programmes. The project work plan is organized in the form of thirteen subprojects, each dedicated to a specific area of activity. A significant part of the budget will be used for competitive calls to complement the collective skills of the Consortium with additional expertise.

## 9.3. International Initiatives

### 9.3.1. Inria International Partners

*9.3.1.1. International Initiatives*

**ECOS Discrelongmem**

Title: On discretization procedures in Non-Gaussian long memory processes with applications in non parametric statistics and time series analysis

International Partner (Institution - Laboratory - Researcher):

Universidad de Valparaiso (Chile) - CIMFAV – Facultad de Ingenieria

PI: E. Tanré (France), S. Torrès (Chile)

Duration: 2016 - 2018

Start year: 2016

Keywords: Approximations of non-Gaussian long-memory processes. Fractional Poisson processes (fPp). Skew Fractional Process (SfP).

## 9.4. International Research Visitors

### 9.4.1. Visits of International Scientists

- E. Mordecki (Universidad de la Reppublica, Uruguay) has been visiting Nancy for two months in February-March 2017.

*9.4.1.1. Internships*

- Ahmed Amine Barnicha

  Subject: Modelling avalanches

  Date: Sept. 2017 - June 2018 (research project)

  Institution: Écoles des Mines de Nancy.

- Quentin Cormier

  Subject: Study of the limit equation associated to a model of interacting neurons

  Date: May 2017 - Aug. 2017

  Institution: Université Pierre et Marie Curie.

- Djibril Gueye

  Subject: Analyse de modèles markoviens couplés pour la température régionalisée

  Date: July 2017 - Oct. 2017

  Institution: AIMS- Senegal.

- Marie Muzzolon

  Subject: Estimation sans paramètres et simulation de Monte Carlo pour les processus ponctuels marqués : lien entre les méthodes ABC et les méthodes de type gradient stochastique.

  Date: April 2017 - Sept. 2017 (research project)

  Institution: Université de Lorraine.

- Fares Omari

  Subject: Analyse de modèles markoviens couplés pour la température régionalisée

  Date: July 2017 - Oct. 2017

  Institution: ENSIIE.

- Medhi Talbi

Subject: Optimisation de portefeuille par une approche de type champ moyen

Date: :March 2017 - July 2018 (research project)

Institution: École Normale Supérieure Paris-Saclay.

*9.4.1.2. Research Stays Abroad*

- M. Deaconu has been invited one week in February to the Institute of Mathematics of the Romanian Academy, Bucarest, by Lucian Beznea.

- C. Fritsch spent three days in Munich in June to start a collaboration with Mehdi Gharasoo (Institute of Groundwater Ecology).

- D. Talay was an invited Professor at Columbia University (New York) in June. He gave a course on ergodic diffusion processes.

- E. Tanré have spent two weeks in Valparaíso (Chile) in December within the ECOS program (PIs: E. Tanré, S. Torres), working with S. Torres (Univ. of Valparaiso).

<center><span style="color:red">**BIGS Project-Team**</span></center>

# 8. Partnerships and Cooperations

## 8.1. National Initiatives

- *Popart (2016-2017)* In the framework of collaboration with A. Deveau of Inra Nancy, A. Gégout-Petit and A. Muller-Gueudin are included in the Inra "Microbial Ecosystems & Metaomics, Call 2016" Project "Popart"for "Regulation of the Poplar microbiome by its host: is the immune system involved ? ". The aim is to develop methodology for the inference of regulation network betwen micro-organisms around Poplar. The specificity of the data is the inflation of zeros that has to be taken into account.

- GDR 3475 Analyse Multifractale, Funding organism: CNRS, Leader: S. Jaffard (Université Paris-Est), Céline Lacaux

- GDR 3477 Géométrie stochastic, Funding organism: CNRS, Leader: P. Calka (Université Rouen), Céline Lacaux

- FHU CARTAGE (Fédération Hospitalo Universitaire Cardial and ARTerial AGEing ; leader : Pr Athanase BENETOS), Jean-Marie Monnez

- RHU Fight HF (Fighting Heart Failure ; leader : Pr Patrick ROSSIGNOL), located at the University Hospital of Nancy, Jean-Marie Monnez

- Project "Handle your heart", team responsible for the creation of a drug prescription support software for the treatment of heart failure, head: Jean-Marie Monnez

- "ITMO Physics, mathematics applied to Cancer" (2017-2019): "Modeling ctDNA dynamics for detecting targeted therapy", Funding organisms: ITMO Cancer, ITMO Technologies pour la santé de l'alliance nationale pour les sciences de la vie et de la santé (AVIESAN), INCa, Leader: N. Champagnat (Inria TOSCA), Participants: A. Gégout-Petit, A. Muller-Gueudin, P. Vallois

- Modular, multivalent and multiplexed tools for dual molecular imaging (2017-2020), Funding organism: ANR, Leader: B Kuhnast (CEA). Participant: T. Bastogne.

## 8.2. European Initiatives

### 8.2.1. Collaborations in European Programs, Except FP7 & H2020

- Photobrain project. AGuIX theranostic nanoparticles for vascular-targeted interstitial photodynamic therapy of brain tumors, project **EuroNanoMed II**, resp.: M. Barberi-Heyob, (2015-2017), participant: T. Bastogne.

- NanoBit Project. Nanoscintillator-Porphyrin Complexes for Bimodal RadioPhotoDynamic Therapy, project **EuroNanoMed II**, resp.: P. Juzenas, (2016-2018), participant: T. Bastogne.

<p style="text-align:center"><span style="color:red">**CAPSID Project-Team**</span></p>

# 8. Partnerships and Cooperations

## 8.1. Regional Initiatives

### 8.1.1. CPER – IT2MP

**Participants:** Marie-Dominique Devignes [contact person], David Ritchie.

Project title: *Innovations Technologiques, Modélisation et Médecine Personnalisée*; PI: Faiez Zannad, Univ Lorraine (Inserm-CHU-UL). Value: 14.4 M€ ("SMEC" platform – Simulation, Modélisation, Extraction de Connaissances – coordinated by Capsid and Orpailleur teams for Inria Nancy – Grand Est, with IECL and CHRU Nancy: 860 k€, approx); Duration: 2015–2020. Description: The IT2MP project emcompasses four interdisciplinary platforms that support several scientific pôles of the university whose research involves human health. The SMEC platform supports research projects ranging from molecular modeling and dynamical simulation to biological data mining and patient cohort studies.

### 8.1.2. LUE – CITRAM

**Participants:** Marie-Dominique Devignes [contact person], Isaure Chauvot de Beauchêne, Bernard Maigret, Philippe Noël, David Ritchie.

Project title: *Conception d'Inhibiteurs du Transfert de Résistances aux agents Anti-Microbiens: bio-ingénierie assistée par des approches virtuelles et numériques, et appliquée à une relaxase d'élément conjugatif intégratif*; PI: N. Leblond, Univ Lorraine (DynAMic, UMR 1128); Other partners: Chris Chipot, CNRS (SRSMSC, UMR 7565); Value: 200 k€ (Capsid: 80 k€); Duration: 2017–2018. Description: This project follows on from the 2016 PEPS project "MODEL-ICE". The aim is to investigate protein-protein interactions required for initiating the transfer of an ICE (Integrated Conjugative Element) from one bacterial cell to another one, and to develop small-molecule inhibitors of these interactions.

### 8.1.3. PEPS – DynaCriGalT

**Participants:** Isaure Chauvot de Beauchêne [contact person], Bernard Maigret, David Ritchie.

Project title: *Criblage virtuel et dynamique moléculaire pour la recherche de bio-actifs ciblant la $\beta$4GalT7, une enzyme de biosynthèse des glycosaminoglycanes*; PI: I. Chauvot de Beauchêne, Capsid (Inria Nancy – Grand Est); Partners: Sylvie Fournel-Gigleux, INSERM (IMoPA, UMR 7365); Value: 15 k€; Duration: 2017–2018. Description: The $\beta$4GalT7 glycosyltransferase initiates the biosynthesis of glycosaminoglycans (GAGs), and is a therapeutical target for small molecules which might correct a defect in the synthesis and degradation of GAGs in rare genetic diseases. Classical approaches to propose active molecules have failed for this target. The DynaCriGalT project combines molecular dynamics modelling of the GAG active site with virtual screening in order to propose a diverse set of small molecules for *in vitro* compound testing.

### 8.1.4. PEPS – InterANRIL

**Participant:** Isaure Chauvot de Beauchêne [contact person].

Project title: *Identification et modélisation des interactions nécessaires à l'activité du long ARN non-codant ANRIL dans la régulation épigénétique des gènes*; PI: Sylvain Maenner, Univ Lorraine (IMoPA, UMR 7365); Value: 20 k€; Duration: 2017–2018. Description: ANRIL is a long non-coding RNA (lncRNA) which has been identified as an important factor in the susceptibility cardiovascular diseases. ANRIL is involved in the epigenetic regulation of the expression of a network of genes via mechanisms that are still largely unknown. This project aims to identify and model the protein-RNA and/or DNA-RNA interactions that ANRIL establishes within the eukaryotic genome.

## 8.2. National Initiatives

### 8.2.1. FEDER – SB-Server

**Participants:** David Ritchie [contact person], Bernard Maigret, Isaure Chauvot de Beauchêne, Sabeur Aridhi, Marie-Dominique Devignes.

Project title: *Structural bioinformatics server*; PI: David Ritchie, Capsid (Inria Nancy – Grand Est); Value: 24 k€; Duration: 2015–2020. Description: This funding provides a small high performance computing server for structural bioinformatics research at the Inria Nancy – Grand Est centre.

### 8.2.2. ANR

#### 8.2.2.1. Fight-HF

**Participants:** Marie-Dominique Devignes [contact person], Bernard Maigret, Sabeur Aridhi, Claire Lacomblez, David Ritchie.

Project title: *Combattre l'insuffisance cardiaque*; PI: Patrick Rossignol, Univ Lorraine (FHU-Cartage); Partners: multiple; Value: 9 m€ (Capsid and Orpailleur: 450 k€, approx); Duration: 2015–2019. Description: This "Investissements d'Avenir" project aims to discover novel mechanisms for heart failure and to propose decision support for precision medicine. The project has been granted € 9M, and involves many participants from Nancy University Hospital's Federation "CARTAGE" (http://www.fhu-cartage.com/). In collaboration with the Orpailleur Team, Marie-Dominique Devignes is coordinating a work-package on network-based science and drug discovery for this project.

#### 8.2.2.2. IFB

**Participants:** Marie-Dominique Devignes [contact person], Sabeur Aridhi, Isaure Chauvot de Beauchêne, David Ritchie.

Project title: *Institut Français de Bioinformatique*; PI: Jean-François Gibrat (CNRS UMS 3601); Partners: multiple; Value: 20 M€ (Capsid: 126 k€); Duration: 2014–2021. Description: The Capsid team is a research node of the IFB (Institut Français de Bioinformatique), the French national network of bioinformatics platforms (http://www.france-bioinformatique.fr). The principal aim is to make bioinformatics skills and resources more accessible to French biology laboratories.

## 8.3. International Initiatives

### 8.3.1. Informal International Partners

Participant: David Ritchie; Project: *Integrative Modeling of 3D Protein Structures and Interactions;* Partner: Rocasolano Institute of Physical Chemistry, Spain. Funding: Inria Nancy – Grand Est ("Nancy Emerging Associate Team").

Participant: Bernard Maigret; Project: *Characterization, expression and molecular modeling of TRR1 and ALS3 proteins of Candida spp., as a strategy to obtain new drugs with action on yeasts involved in nosocomial infections;* Partner: State University of Maringá, Brasil.

Participant: Bernard Maigret; Project: *Fusarium graminearum target selection;* Partner: Embrapa Recursos Geneticos e Biotecnologia, Brasil.

Participant: Bernard Maigret; Project: *The thermal shock HSP90 protein as a target for new drugs against paracoccidioidomicose;* Partner: Brasília University, Brasil.

Participant: Bernard Maigret; Project: *Protein-protein interactions for the development of new drugs;* Partner: Federal University of Goias, Brasil.

## 8.4. International Research Visitors

### 8.4.1. Visits of International Scientists

#### 8.4.1.1. Internships

Isis Grenier Capoci from the State University of Maringá, Brasil visited the team (through the programme "Doutorado Sanduiche no Exterior") to develop new inhibitors of *Candida albicans* TRR1 under the supervision of Bernard Maigret.

<span style="color:red">**MIMESIS Team**</span>

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

### 9.1.1. *Institute of Image-Guided Surgery (IHU) Strasbourg*

The Institute of Image-Guided Surgery of Strasbourg develops innovative surgery to deliver personalized patient care, combining the most advanced minimally invasive techniques and the latest medical imaging methods.

Project *CIOS Alpha Fusion* funded by IHU Strasbourg has started at the beginning of 2017. The goal of the project is to develop a solution for real-time, accurate, image fusion between 3D anatomical data and 2D X-ray images. This requires to spatially align these two imaging datasets with each other, knowing that a deformation has occurred between the 2 acquisitions. We consider two different cases, of increasing scientific complexity: static image fusion using 2 fluoroscopic images taken at 2 different angles, and dynamic image fusion using a single fluoroscopic image. We also consider two additional scenarios: in the first one, a 3D image or a 3D model has been obtained from a preoperative CTA or MRA while in the second scenario it has been acquired using an intra-operative contrast-enhanced CBCT. In the second case, tissue deformation between the 2D and 3D data is significantly reduced.

The project team involves scientists from the MIMESIS team at Inria, engineers from Siemens as industrial partner, and clinicians from the NHC hospital and IHU.

### 9.1.2. *Research and Clinical Partners*

At the regional level, the MIMESIS team collaborates with

> **ICube Automatique Vision et Robotique (AVR):** We have been collaborating with the medical robotics team on percutaneous procedures, in particular robotized needle insertion (with Prof. Bernard Bayle), and needle tracking in medical images (with Elodie Breton). We are also collaborating with Jonathan Vappou on elastography.

> **ICube Informatique Géométrique et Graphqiue (IGG):** MIMESIS joined the IGG team and develops collaboration in the domain of dynamic topologies, mainly through the use of the CGoGN framework. CGoGN is a C++ library for the manipulation of meshes. It implements combinatorial maps and their multiresolution extensions and has been used in various high level application like the simulation of crowds of autonomous agents and the simulation of cuts, tears and fractures in the context of surgical simulations.

> **Nouvel Hôpital Civil, Strasbourg:** since 2014 we have been working with Prof. David Gaucher, an ophthalmologist and expert in retina surgery. This led to the submission of the ANR project RESET which started in March 2015. We also collaborate with Prof. Patrick Pessaux, a surgeon who helps us in the context of the SOFA-OR project.

## 9.2. National Initiatives

### 9.2.1. *ADT (Action de Développement Technologique)*

Team MIMESIS received a support for the development of the SOFA framework through two ADTs:

**DynMesh** (Sep 2015 – Aug 2017): The objectives of the ADT was the coupling of SOFA, the physical simulation platform supported by Inria, and CGoGN, the mesh management library developed within the ICube lab at Strasbourg. The goal is to extend the physical engine SOFA with the topological kernel of CGoGN that supports a wide variety of mesh and many local remeshing operations. The coupling of both software libraries will provide users of physical engines with new tools for the development of simulations involving topological changes like cutting, fracturing, adaptation of the resolution or improving contact management or collision detection. The impacts are numerous and will be operated directly within the MIMESIS Team, with our partners or through the establishment of new collaborations.

**ASNAP** (*Accélération des Simulations Numériques pour l'Assistance Peropératoire*, Jan 2017 – Dec 2018). We are partners of ADT ASNAP with principal investigator being Inria team CAMUS. The goal of the project is a significant acceleration of physics-based simulations developed by MIMESIS. The technologies such as Apollo, XFOR, ORWL, developed by team CAMUS are used to optimize the execution of different components of framework SOFA, taking into account the possibilities provided by modern CPUs and GPGPUs. Since team CAMUS is also located in Strasbourg, the project benefits from the geographical location: an engineer Maxim Mogé was recruited, starting from 01/01/2017 and he shares his time between the two teams.

### 9.2.2. ANR (Agence Nationale de la Recherche)

MIMESIS participates in the following ANR projects:

**RESET**: This project started in March 2015 and will end in May 2017. Its objective is to develop a high-fidelity training system for retinal surgery. Retinal surgery is an increasingly performed procedure for the treatment of a wide spectrum of retinal pathologies. Yet, as most micro-surgical techniques, it requires long training periods before being mastered. This simulator is built upon our scientific expertise in the field of real-time simulation, and our success story for technology transfer in the field of cataract surgery simulation (MSICS simulation developed for the HelpMeSee foundation).

**Coordinator**: MIMESIS

**Partners**: the InSimo company, the AVR team of the ICube lab.

**EVEREST**: The overall objective of the EVEREST project is thus to bring a leap forward in factorization of large sparse tensors in order to improve the accessibility, completeness and reliability of real-world KBs. This line of research could have a huge impact in industry (Semantic Web, biomedical applications, etc.). For that reason, Xerox Research Center Europe is supporting this project and will supply data, provide expertise and ease industrial transfer. This proposal is also consistent with the long-term research direction of its principal partner, Heudiasyc, since it contributes in several aspects of the 10 years LabEx program on *Technological Systems of Systems* started in 2011.

**Coordinator**: IHU Strasbourg

**Partners**: Inria, IRCAD, University of Strasbourg, Siemens Healthcare, Karl Storz GmbH., University of Twente

### 9.2.3. Inria Collaborations

MIMESIS is closely connected to the SOFA Consortium, created by Inria in November 2015 with the objective to support the SOFA community and encourage contributions from new SOFA users. The Consortium should also be a way to better answer to the needs of academic or industrial partners. MIMESIS actively participates at the development of SOFA and contributed to the evolution of the framework. Moreover, MIMESIS also participates in an initiative aiming at verification and validation of codes and algorithms of SOFA.

Further, MIMESIS actively collaborates with the following Inria teams:

**MAGRIT:** The team at Inria Grand Est focuses on research in computer vision and is also actively involved in computer-based solutions for the planning or the simulation of interventional radiology procedures, with a strong collaboration with the CHU in Nancy. We collaborate with MAGRIT in the area of interventional radiology and augmented reality. Currently, two PhD thesis are co-supervised by researcher from Magrit: the PhD thesis of Jaime Garcia Guevara and Raffaella Trivisonne.

**CAMUS:** The team focuses on developing, adapting and extending automatic parallelizing and optimizing techniques, as well as proof and certification methods, for the efficient use of current and future multi-core processors. Currently, we collaborate with team CAMUS on parallelization of framework SOFA in ADT project ASNAP.

**DEFROST:** The team conducts research in soft robotics. We continue mutual interaction with DEFROST mainly in the context of contact modeling.

### 9.2.4. National Collaborations

At the national level, the MIMESIS team collaborates with:

**The TIMC laboratory***(Techniques de l'Ingénierie Médicale et de la Complexité)* in Grenoble: this large research group has a strong background in computer-aided surgery, medical imaging, registration, statistical and bio-mechanical modeling. We have regular interactions with various members of this group. We are collaborating with Yohan Payan (DR CNRS) on the modeling and simulation of the brain shift. A common PhD thesis started on that topic in late 2014. Other areas of interest are in the field of advanced soft tissue modeling and computer aided surgery.

**The LML laboratory***(Laboratoire de Mécanique de Lille)*: a French research laboratory (UMR CNRS 8107) part of the Carnot institute ARTS. With more than two hundred researchers, LML focuses on the following research areas: mechanical reliability and Tribology, fluid mechanics, civil engineering and soil mechanics.

**Hôpital Paul-Brousse**: a hospital in South Paris. We collaborate with *Centre Hépato-Biliaire* via the co-supervision of the Ph.D. thesis of Nicolas Golse, MD, who is a surgeon at the center.

## 9.3. European Initiatives

### 9.3.1. FP7 & H2020 Projects

Program: H2020, Innovative Training Network, MSCA

Project acronym: HiPerNav

Project title: High performance soft tissue navigation

Coordinator: Oslo University Hospital

Other partners: SINTEF Trondheim, University of Bern

Abstract: HiPerNav is an Innovative Training Network (ITN) funded through a Marie Skłodowska-Curie grant. There will be 14 fully funded and 2 partially funded PhD's working on the project. The project aims to improve soft tissue navigation through research and development, to improve several bottleneck areas:

- Creating effective pre-operative model(s) and planning
- Faster and more accurate intra-operative model updates
- Faster and more accurate model-to-patient registration
- More intuitive user-interaction and effective work flow
- Usage of high performance computing (e.g. GPU)

### 9.3.2. Informal Collaborations

**University of Twente:** Thanks to our clinical partner IHU, we collaborate with Prof. Stefano Stramigioli, head of a group at Robotics and Mechatronics laboratory.

**Faculty of Informatics, Masaryk University, Czech Republic:** We collaborate on simulation of living cells in fluorescent microscopy. The collaboration resulted in a presentation at an international conference [29] and a journal paper [18].

**Team Legato, University of Luxembourg:** we have an active collaboration with Prof. Stéphane Bordas on error estimation in real-time simulations of deformable objects. The collaboration resulted in a common publication [16].

# 9.4. International Initiatives

The MIMESIS team actively collaborates with following international partners:

**CIMIT & Harvard Medical School, Boston, USA:** We collaborate on a project REBOASim in the contect of interventional radiology, , in particular the design and development of a hardware interface for tracking catheters and guidewires. The common DoD project REBOASim focuses on development of the physics-based models for catheter and guidewire motion, blood flow and graphical rendering towards a novel simulator for REBOA that will include physical vascular access, simulated passage of the IR instruments into the aorta with accompanying training/educational content, device withdrawal and closure: Duration of the project: Feb 2017 – Feb 2019.

# 9.5. International Research Visitors

## 9.5.1. Visits of International Scientists

From Feb 2017 to July 2017, **Prof. Adam Wittek** joined team MIMESIS as a visiting scientist. Prof. Wittek is with Intelligent Systems for Medicine Laboratory, School of Mechanical and Chemical Engineering at the University of Western Australia, Perth. His research focuses on patient-specific biomechanical modeling and he has published an important number of high-quality publications on this topic with more than 2,000 citations.

During his stay, Prof. Wittek provided his highly valuable expertise in various domains of patient-specific simulations and advanced techniques of modeling of deformations in soft tissues such as meshless methods. He was also involved in projects related to insertions of flexible needles into soft tissues.

### 9.5.1.1. Internships

From Jul 2017 to Dec 2017, Vincent Magnoux, a Canadian PhD student from École polytechnique de Montréal, joined MIMESIS as an international intern. During his stay, he has worked on implementing and validating a meshless method for computing organ deformation. This work also involved exploring methods to accelerate these computations on multi-core systems for an interactive simulation.

<p style="text-align:center;color:red;font-weight:bold;">NEUROSYS Project-Team</p>

# 8. Partnerships and Cooperations

## 8.1. Regional Initiatives

Within the *Contrat de Projet État Région (CPER) IT2MP* 2015-2020 on *Technological innovations, modeling and Personalized Medicine*, we are contributing on platform SCIARAT (*cognitive stimulation, Ambient Intelligence, Robotic assistance" and Telemedicine*) observing electroencephalographic activity of humans during motor tasks. Contact in Neurosys is Laurent Bougrain.

## 8.2. National Initiatives

Inria project-Lab BCI-LIFT, Brain-Computer Interfaces: Learning, Interaction, Feedback, Training, Maureen Clerc, 2015-2018, 7 Inria project-teams (Aramis, Athena, Demar, Hybrid, Mjolnir, Neurosys, Potioc), university of Rouen, Dycog team at Centre de Recherche en Neurosciences de Lyon.

BCI-LIFT is a research initiative to reach a next generation of non-invasive Brain-Computer Interfaces (BCI), more specifically BCI that are easier to appropriate, more efficient, and suit a larger number of people. With this concern of usability as our driving objective, we build non-invasive systems that benefit from advanced signal processing and machine learning methods, from smart interface design, and where the user immediately receives supportive feedback. What drives this project is the concern that a substantial proportion of human participants is currently categorized "BCI-illiterate" because of their apparent inability to communicate through BCI. Through this project we aim at making it easier for people to learn to use BCI, by implementing appropriate machine learning methods and developing user training scenarios.

## 8.3. International Initiatives

### 8.3.1. *Inria International Partners*

#### 8.3.1.1. *Informal International Partners*

- We have an ongoing collaboration with Prof. Motoharu Yoshida at Ruhr university Bochum, Germany, aiming to study the role of persistent firing neurons in memory and more specifically in neural network synchronization. M. Yoshida provides us with biological data that we combine with simulations to test hypotheses on memory formation (L. Buhry).
- We also collaborate with Prof. LieJune Shiau (university of Houston, Texas, USA) on more theoretical approaches concerning the role of intrinsic neuronal dynamics in network synchronization and brain oscillations (L. Buhry).
- We also collaborate with Anton Popov (Kiev Polytechnic Institute, Ukraine) on feature extraction of brain signal and deep learning (L. Bougrain).

## 8.4. International Research Visitors

### 8.4.1. *Visits of International Scientists*

- Anton Popov, Ass. Prof, Kiev Polytechnic Institute, Ukraine, 5 weeks (May 2017)
- Yevgeniy Karplyuk, Ass. Prof, Kiev Polytechnic Institute, Ukraine, 3 weeks (May 2017)
- Widodo Budiharto, Full Prof, university of Binus, Indonesia, 1 week (Jan 2017)

#### 8.4.1.1. *Internships*

- Oleksii Avilov, Erasmus+, Kiev Polytechnic Institute, Ukraine, Jan-Jul 2017
- Ivan Kotiuchi, Erasmus+, Kiev Polytechnic Institute, Ukraine, Jan-Jul 2017

<span style="color:red">**TONUS Team**</span>

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

The thesis of Pierre Gerhard devoted to numerical simulation of room acoustics is supported by the Alsace region. It is a joint project with CEREMA (Centre d'études et d'expertise sur les risques, l'environnement, la mobilité et l'aménagement) in Strasbourg.

## 9.2. National Initiatives

### 9.2.1. Contracts with Industry

We are involved in a common project with the company AxesSim in Strasbourg. The objective is to help to the development of a commercial software for the numerical simulation of electromagnetic phenomena. The applications are directed towards antenna design and electromagnetic compatibility. This project was partly supported by DGA through "RAPID" (régime d'appui à l'innovation duale) funds. A CIFRE PhD has started in AxesSim on the same kinds of subjects in March 2015 (Bruno Weber). The new project is devoted to the use of runtime system in order to optimize DG solvers applied to electromagnetism [10]. The resulting software will be applied to the numerical simulation of connected devices for clothes or medicine. The project is supported by the "Banque Publique d'Investissement" (BPI) and coordinated by the Thales company.

### 9.2.2. ANR

ANR project PEPPSI (models for edge plasma physic in Tokamak) in *Programme Blanc* SIMI 9, started in 2013, ended this year.
**Participants:**  David Coulette, Giovanni Manfredi [coordinator], Sever Hirstoaga.

### 9.2.3. IPL FRATRES

The TONUS project belongs to the IPL FRATRES (models and numerical methods for Tokamak).
Funded by the IPL, Xiaofei Zhao was a post-doctoral fellow until September 2017, under the joint supervision of Nicolas Crouseilles (team IPSO, Inria Rennes) and Sever Hirstoaga.

### 9.2.4. IPL C2S@exa

The TONUS and HIEPACS projects have obtained the financial support for the PhD thesis of Nicolas Bouzat thanks to the IPL C2S@exa (computational sciences at exascale). Nicolas Bouzat works at CEA Cadarache and is supervised locally by Guillaume Latu; the PhD advisors are Michel Mehrenberger and Jean Roman.

### 9.2.5. HPC resources

- GENCI project *Simulation numérique des plasmas par des méthodes semi-lagrangiennes et PIC adaptées*: 450 000 scalar computing hours on CURIE_standard (January 2016-January 2017). Coordinator: Michel Mehrenberger
  **Participants:**  Sever Hirstoaga, Guillaume Latu, Michel Mehrenberger, Thi Nhung Pham, Christophe Steiner, Yann Barsamian.

- GENCI project *Simulations 3D de plasmas deux espèces avec des méthodes particulaires et semi-lagrangiennes*: 400 000 scalar computing hours accepted in October 2017 on supercomputer OCCIGEN. Coordinator: Sever Hirstoaga
  **Participants:**  Yann Barsamian, Sever Hirstoaga, Michel Mehrenberger.

- PRACE project *SME HPC Adoption Programme in Europe: full simulation of an electromagnetic wave inside and ouside a fully modeled human body*: 40 000 GPU computing hours accepted in October 2017 on supercomputer Piz Daint. Coordinator: Bruno Weber
  **Participants:**  Philippe Helluy, Bruno Weber.

## 9.3. European Initiatives

### 9.3.1. FP7 & H2020 Projects

#### 9.3.1.1. EUROfusion 2015-2017

- Eurofusion Enabling Research Project ER15-IPP01 (1/2015-12/2017) "Verification and development of new algorithms for gyrokinetic codes" (Principal Investigator: Eric Sonnendrücker, Max-Planck Institute for Plasma Physics, Garching).
  **Participants:**  Philippe Helluy, Sever Hirstoaga, Michel Mehrenberger.
- Eurofusion Enabling Research Project ER15-IPP05 (1/2015-12/2017) "Global non-linear MHD modelling in toroidal geometry of disruptions, edge localized modes, and techniques for their mitigation and suppression" (Principal Investigator: Matthias Hoelzl, Max-Planck Institute for Plasma Physics, Garching).
  **Participant:**  Emmanuel Franck.

## 9.4. International Initiatives

### 9.4.1. Participation in Other International Programs

**Participants:**  David Coulette, Conrad Hillairet, Emmanuel Franck, Philippe Helluy [local coordinator].

ANR/SPPEXA "EXAMAG" is a joint French-German-Japanese project. Its goal is to develop efficient parallel MHD solvers for future exascale architectures. With our partners, we plan to apply highly parallelized and hybrid solvers for plasma physics. One of our objectives is to develop Lattice-Boltzmann MHD solvers based on high-order implicit Discontinous Galerkin methods, using SCHNAPS and runtime systems such as StarPU.

## 9.5. International Research Visitors

### 9.5.1. Visits of International Scientists

Christian Klingenberg from Würzburg university was invited several times in 2017, by Philippe Helluy.

Roberto Ferretti was invited one month in 2017 at IRMA, by Michel Mehrenberger, for working on the stability of semi-Lagrangian schemes.

### 9.5.2. Visits to International Teams

#### 9.5.2.1. Research Stays Abroad

Philippe Helluy, Emmanuel Franck and David Coulette visited Christian Klingenberg at Würzburg university.

<p style="text-align:center"><span style="color:red">**COAST Project-Team**</span></p>

# 7. Partnerships and Cooperations

## 7.1. Regional Initiatives

### 7.1.1. Region Lorraine TV Paint (2016–2017)
**Participants:** Claudia-Lavinia Ignat [contact], Gérald Oster, Quang Vinh Dang, Matthieu Nicolas.

Partners: TVPaint Development, Inria COAST project-team

Website: https://www.tvpaint.com/

This is a project in collaboration with TVPaint Development financed by Region Lorraine. The goal is to contribute to the creation of a collaborative system dedicated to animation movies, that allows to manipulate high quantities of digital artifacts in a collaborative way.

### 7.1.2. Region Grand Est TV Paint (2017–2019)
**Participants:** Claudia-Lavinia Ignat [contact], Gérald Oster.

Partners: TVPaint Development, Inria COAST project-team

Website: https://www.tvpaint.com/

This is a follow-up project in collaboration with TVPaint Development financed by Region Grand Est.

The goal is to contribute to the creation of a collaborative system dedicated to manage the production of animated movies. This system has to manipulate a large amount of data in a safe and secure manner. Based on the previously proposed architecture and prototype, this project intends to design and implements a commercial product. In the framework of this project, we bring our expertise in data management, business process management, distributed systems and collaborative systems.

Coast funding : 81,600 €

## 7.2. National Initiatives

### 7.2.1. OpenPaas NG (2015–2019)
**Participants:** Claudia-Lavinia Ignat, François Charoy [contact], Gérald Oster, Olivier Perrin, Jean-Philippe Eisenbarth, Phillippe Kalitine, Matthieu Nicolas, Mohammed Riyadh Abdmeziem, Kahina Bessai, Victorien Elvinger, Quentin Laporte Chabasse, Hoai Le Nguyen, Hoang Long Nguyen.

Partners: Linagora, XWiki SAS, Nexedi, COAST project-team (Université de Lorraine, LORIA), DaScim team (LIX).

Website: http://www.open-paas.org/

This project is financed by BpiFrance and involves French industrial leaders in open-source software development (Linagora, Nexedi, XWiki) and academic partners in collaborative work (COAST team) and recommender systems (DaScim team, LIX). The goal of the project is to develop next generation cloud enabled virtual desktop based on an Enterprise Social Network to provide advanced collaborative and recommendation services. COAST team is responsible of the work package dedicated to the design of the peer-to-peer collaborative middleware. In this context, we bring our expertise on data replication for collaborative data in peer-to-peer environments and on trust and access control and identity management in distributed collaborative information systems.

## 7.3. International Initiatives

### 7.3.1. Inria Associate Teams Not Involved in an Inria International Labs

#### 7.3.1.1.  USCOAST2

Title: User Studies on Trustworthy Collaborative Systems

International Partner (Institution - Laboratory - Researcher):

Wright State University (United States) - Department of Psychology, Knoesis - Valerie Shalin

Start year: 2016

See also: http://uscoast.loria.fr

The proposed project addresses the perception of trust by users, the appropriateness of a trust-based security approach and the role of trust metrics in the management of distributed work. The main challenge of this project is how to measure trust based on user behaviour and to verify by means of experimental studies with users that the trust-based mechanism is acceptable by users. We plan to apply this trust-based mechanism for two types of applications. The first one is collaborative editing where user trust will be computed based on the quality of user contributions for a document or project. The second type of application is in the management of work over a large group of people in order to conduct efficient, high-yield, high-density real time crowdsourcing activities.

Partners of USCOAST2 project have complementary expertise. COAST provides expertise in collaborative methods, systems and related technologies. Coast will propose algorithms that track and manipulate trust metrics. Kno.e.sis provides expertise on the analysis of human work-related behavior, including methods of data collection and data analysis, as well as a theoretical foundation for the evaluation of human performance. Knoesis will analyse trust from a psychological phenomenon point of view.

## 7.4. International Research Visitors

### 7.4.1. Visits of International Scientists

Valerie Shalin from Wright State University spent one month and a half (May-July 2017) in our team as part of the USCoast2 Inria associated team.

Weihai Yu from Arctic University of Norway spent two weeks in March 2017 in the team as invited professor.

### 7.4.2. Visits to International Teams

#### 7.4.2.1. Research Stays Abroad

- Béatrice Linot spent 3 months at Wright State University as part of our collaboration with Dr Valerie Shalin and Prof. Amit Sheth, funded by her LUE PhD grant.

<p style="text-align:center"><span style="color:red">**MADYNES Team**</span></p>

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

### 9.1.1. *6PO Research Region Lorraine and UL project*
**Participants:** Emmanuel Nataf, Ye-Qiong Song, Laurent Ciarletta [contact].

*Funded by Region Lorraine and Université de Lorraine since 2013. Adel Belkadi (CRAN & LORIA) is co-directed by L. Ciarletta and Didier Theilliol (CRAN correspondant).*

6PO ("Systèmes Cyber-Physiques et Commande Coopérative Sûre de Fonctionnement pour une Flotte de Véhicules sans Pilote" ) is a joint research project between the Loria and CRAN laboratories. As a part of the Aetournos ecosystem, it also aims at researching solutions for safe formation flying of collaborative UAVs seen as part of a collection of Cyber Physical Systems mixing computer science and automation solutions.

It is reinforced by a PhD grant from this federation that started in october 2014 (*Conception de méthodes de diagnostic et de tolérance aux fautes des systèmes multi-agents: Application à une flotte de véhicules autonomes*, Adel Belkadi) and has been successfully defended in october 2017.

This led to common publications, notably on the subjects of the robust control of a fleet or flock of UAVs (with or without leader, using agents paradigms and particle swarm optimisation [10] and [31]).

The project provides common use cases and scientific challenges that serve as catalysts for collaboration between teams from different research topics :

- Cyber Physical Systems, Real Time, Quality of service, Performance and Energy in Wireless Sensors and Activator Networks
- Collaborative, communicating autonomous systems and Unmanned Vehicles
- Safety, Dependabilty, Reliability, Diagnosis, Fault-Tolerance

### 9.1.2. *Hydradrone FEDER Région Lorraine project*
**Participants:** Zhixiang Liu, Laurent Ciarletta [contact].

*Feder funding*

The Madynes team has been working on the Hydradrone project since July 2014. It started as a collaborative R&D initiative funded by *Région Lorraine* and is now FEDER funded. This project started as a joint work between Madynes and PEMA (*Pedon Environnement et Milieux Aquatiques*), an SME/VSE (small and medium size Entreprise, PME/TPE). The consortium now includes Alerion another VSE, a spinoff from Loria/UL.

It consists in developing a new solution for the surveillance of aquatic environment, the Hydradrone:

- starting with an actual need for automated and remote operation of environmental sensing expressed by PEMA
- based on an hybrid UxV (Unmanned Air, Surface... Vehicle),
- some Cyber Physical bricks in coherence with the Alerion's concepts (ease of use, safety, autonomy)
- and an integration in the Information System of the company

PEMA, as an environmental company, provides the use cases and terrain (and business) validation, while Alerion is working on the integration and engineering of the solution.

This third year has been dedicated to the development of the surface controller for the Hydradrones along with the development of a new small version, and the integration of environmental sensors. The project has been extended towards the summer 2018 in order to finish the integration and tests.

### 9.1.3. *Satelor AME Lorraine regional project*

**Participants:** François Despaux, Bernardetta Addis, Evangelia Tsiontsiou, Ye-Qiong Song [contact].

The Madynes team is involved in Satelor, a regional research and development project funded by the AME (Agence de Mobilisation Economique) of Lorraine (October 2013 – September 2017). The consortium includes academic (Univ. of Lorraine, Inria), medical (OHS) and industrial (Diatelic-Pharmagest (lead), ACS, Kapelse, Salendra, Neolinks) partners. It aims at developing innovative and easily deployable ambient assisted living solutions for their effective use in the tele-homecare systems. The Madynes team is mainly involved in the data collection system development based on wireless sensors networks and IoT technology. The first topic consists in defining the basic functions of the future SATEBOX – a gateway box for interconnecting in-home sensors to the medical datacenter, based on our previously developed MPIGate software. A beta-version prototype of the future Satebox gateway has been achieved. It now includes Zigbee wireless sensors, EnOcean battery-free sensors and Bluetooth Low Energy sensors. It provides a low-cost and easily deployable solution for the daily activity monitoring. After its first real-world deployment at a OHS hospital room, a second prototype testbed has been realized at one EHPAD including several rooms. The second topic is related to improve the data transfer reliability while still keep minimum energy consumption. This has led us to focus on the multi-hop mesh network topology with multi-constrained QoS routing problem (PhD thesis of Evangelia Tsiontsiou). The third topic is UWB-based indoor localization and its use for tracking and detecting falls of the elderlies. Experiments have shown a great benefice of multi-sensor fusion (e.g. localization + accelerometer) for increasing the detection accuracy.

## 9.2. National Initiatives

### 9.2.1. *ANR*

#### 9.2.1.1. *ANR BottleNet*
**Participants:** Isabelle Chrisment [contact], Thibault Cholez, Vassili Rivron.

The Quality of Experience (QoE) when accessing the Internet, on which more and more human activities depend on, is a key factor for today's society. The complexity of Internet services and of user's local connectivity has grown dramatically in the last years with the proliferation of proxies and caches at the core and access technologies at the edge (home wireless and 3G/4G access), making it difficult to diagnose the root cause of performance bottlenecks. The objective of BottleNet is to deliver methods, algorithms, and software systems to measure end-to-end Internet QoE and to diagnose the cause of experienced issues. The result can then be used by users, network and service operators or regulators to improve the QoE.

The ANR BottleNet project (https://project.inria.fr/bottlenet) started in February 2016. It involves many partners in the field of computer networks and QoE: Inria Muse and Diana teams, Lille1 University, Telecom Sud-Paris, Orange, IP-Label. The objective of BottleNet is to deliver methods, algorithms, and software systems to measure Internet QoE and diagnose the root cause of poor Internet QoE. Our goal calls for tools that run directly at users' devices. We plan to collect network and application performance metrics directly at users' devices and correlate them with user perception to model Internet QoE, and to correlate measurements across users and devices to diagnose poor Internet QoE. This data-driven approach is essential to address the challenging problem of modeling user perception and of diagnosing sources of bottlenecks in complex Internet services. BottleNet will lead to new solutions to assist users, network and service operators as well as regulators in understanding Internet QoE and the sources of performance bottleneck.

#### 9.2.1.2. *ANR Doctor*
**Participants:** Thibault Cholez [contact], Xavier Marchal, Daishi Kondo, Olivier Festor.

The DOCTOR project http://www.doctor-project.org is an applied research project funded by the French National Research Agency (ANR), grant <ANR-14-CE28-000>, and supported by the French Systematic cluster. The project started on December 2014 for three years plus one year of extension (2018) to align the scientific production with the budget consumption. It involves five partners specialized in network monitoring and security: Orange Labs (lead), Thales, Montimage, Université de technologie de Troyes and LORIA/CNRS. The DOCTOR project advocates the use of virtualized network equipment (Network Functions Virtualization), to enable the co-existence of new Information-Centric Networking stacks (e.g.: Named-Data Networking) with IP, and the progressive migration of traffic from one stack to the other while guaranteeing the good security and manageability of the network. Therefore in DOCTOR, the main goals of the project are: (1) the efficient deployment of NDN as a virtualized networking environment; (2) the monitoring and security of this virtualized NDN stack.

This year, we focused on the second workpackage dedicated to security. We did a joint work with UTT investigating the impact on the Content Poisoning Attack on the NDN architecture [21]. We also wrote a book chapter about our use of NDN and NFV technologies to deploy an NDN network while providing advanced monitoring and security functions [35].

We also improved our HTTP/NDN gateway that will be soon released for the community and which design and evaluation will be submitted in a journal.

The next (and last) year of the project will be dedicated to the orchestration of our virtualized NDN architecture to manage its performance and security, and to the deployment of a testbed carrying real user traffic.

### 9.2.1.3. FUI HUMA (01/09/2015-31/08/2018)

**Participants:** Giulia de Santis, Soline Blanc, Sofiane Lagraa, Jérôme François [contact], Abdelkader Lahmadi, Isabelle Chrisment.

The HUMA project (*L'HUmain au cœur de l'analyse de données MAssives pour la sécurité*) is funded under the national FUI Framework (Fonds Unique Interministeriel) jointly by the BPI (Banque Publique d'Investissement) and the Région Lorraine. It has been approved by two competitive clusters: Systematic and Imaginove. The consortium is composed of three academic (ICube, Citi, Inria) and five industrial (Airbus Defence and Space, Intrinsec, Oberthur, Wallix, Sydo) partners. The leader is Intrinsec.

This project targets the analysis of Advanced Persistent Threat. APT are long and complex attacks which thus cannot be captured with standard techniques focused on short time windows and few data sources. Indeed, APTs may last for several months and involve multiple steps with different types of attacks and approaches. The project will address such an issue by leveraging data analytics and visualization techniques to guide human experts, which are the only one able to analyze APT today, rather than targeting a fully automated approach.

In 2017, our contribution focused on defining a graph-mining technique to discover dependencies among security events clustering techniques in order to group individual events into a common one. We applied our technique to darknet data as shown in section 7.2.1 . In addition, we also start the modeling of an attacker process by considering the first phase of APT, *i.e.* the reconnaissance phase by analyzing scanning activities using Hidden Markov Model (7.2.1 ). We also technically contribute to the definition of APT scenarios by providing a very stealthy scanning approach (Wiscan described in 7.1.2 ). Finally, from a project management point of view, Inria is in charge of leading the work-package related to data analytics technique for analyzing security probe events.

### 9.2.1.4. Inria-Orange Joint Lab

**Participants:** Jérôme François [contact], Rémi Badonnel, Olivier Festor, Maxime Compastié, Paul Chaignon.

The challenges addressed by the Inria-Orange joint lab relate to the virtualization of communication networks, the convergence between cloud computing and communication networks, and the underlying software-defined infrastructures. This lab aims at specifying and developing a GlobalOS (Global Operating System) approach as a platform or a software infrastructure for all the network and computing resources required by the Orange network operator. Our work, started in November 2015, concerns in particular monitoring methods for

software-defined infrastructures, and management strategies for supporting software-defined security in multi-tenant cloud environments. We have specified a management framework dedicated to cloud software-defined security. It relies on on-the-fly generation and execution of unikernels in order to build highly-constrained configurations. The solution has been evaluated through extensive series of experiments, based on a proof-of-concept prototype using MirageOS. Results show that the costs induced by security mechanisms integration are relatively limited, and unikernels are well suited to minimize risk exposure.

### 9.2.1.5. ANR FLIRT

**Participants:** Olivier Festor [contact], Rémi Badonnel, Thibault Cholez, Jérôme François, Abdelkader Lahmadi, Laurent Andrey.

FLIRT (Formations Libres et Innovantes Réseaux & Télécom) is an applied research project leaded by the Institut Mines-Télécom, for a duration of 4 years. It includes 14 academic partners (engineering schools including Telecom Nancy), 3 industrial partners (Airbus, Nokia Group and Orange), 2 innovative startups (the MOOC agency, and Isograd), as well as 3 professional or scientific societies (Syntec Numérique, Unetel, SEE). The project objective is to build a collection of 10 MOOCs (Massive Open Online Courses) in the area of networks and telecommunications, 3 training programmes based on this collection, as well as several innovations related to pedagogical efficiency (such as virtualization of practical labs, management of student cohorts, and adaptative assessment). The Madynes team is leading a working group dedicated to the building of a MOOC on network and service management. This MOOC, whose first session will open end of 2018, covers the fundamental concepts, architectures and protocols of the domain, as well as their evolution in the context of future Internet, and includes practical labs and exercises using widely-used tools and technologies.

## 9.2.2. Technological Development Action (ADT)

### 9.2.2.1. ADT UASS

The goal of this ADT provides assistance in developing the Aetournos platform to help in the UAV Challenge Medical Express. Through this ADT, funded by Inria, Raphaël Cherfan has coordinated students work on the platform and tutored the Aetournos team for the 2016 Outback Joe Search and Rescue / Medical Express Challenge, and help in the design and buidling of a novel Hybrid UAV.

### 9.2.2.2. ADT VERTEX

This ADT started in 2016 and will end on 2018. The Madynes project is a major partner funded at the level of 120k€. ADT VERTEX built upon the foundations of the Grid'5000 testbed aims to reinforce and extend it towards new use cases and scientific challenges. Several directions are being explored: networks and Software Defined Networking, Big Data, HPC, and production computation needs. Previously developed prototypes are also being consolidated, and the necessary improvements to user management and tracking are also being performed.

### 9.2.2.3. ADT SDT

Built on the Distem emulator, that enables the creation of virtual experimental environments from clusters of homogeneous machines, this project aims at enlarging the scope of use of Distem to additional fields: *Software Defined Networking*, *Named Data Networking*, *Big Data*. In addition, we will explore *temporal dilation* as a technique to study future infrastructures.

The project started in 2017 and will end in 2019.

### 9.2.2.4. ADT RIOT

RIOT ADT is a multi-site project with Infine and Madynes teams, which started in December 2016 for a duration of two years. The high-level objective is to (1) contribute open source code, upstream, to the RIOT code base, (2) coordinate RIOT development within Inria, with other engineers and researchers using/developing RIOT, (3) coordinate RIOT development outside Inria, help maintain the RIOT community at large (see http://www.riot-os.org and http://www.github.com/RIOT-OS/RIOT) which aims to become the equivalent of Linux for IoT devices that cannot run Linux because of resource constraints.

This year MADYNES team has mainly contributed to the efficient MAC layer protocol implementation issues. We have built a general MAC protocol module (gnrc mac module) for providing critical development tools for MAC protocol developers in the RIOT community. Based on these generic functions, we have developed two duty-cycled MAC protocols lw-MAC and GoMacH which are above IEEE802.15.4. lw-MAC is a single channel MAC protocol that has similar principle of X-MAC and ContikiMAC. GoMacH [26] is a traffic-adaptive multi-channel MAC protocol for IoT which exhibes low power consumption and high throughput performance. Both are integrated into the RIOT IoT protocol stack and merged into RIOT master branch. They are publically available in RIOT open source github.

### 9.2.2.5. ATT AMICS

The ATT AMICS is run in cooperation with the High Security Lab (HSL). The goal is to develop a customizable security analytics stack as a service. The added value of the HSL is to cross-correlate customer data with Internet probes hosted at HSL collecting tons of security data. Indeed, the basic service provided to potential customer is a VPN on top of which custom modules can be added. In 2017, we setup the VPN elements and also developed a flexible framework for security analysis. Different moddules have already been defined and implemented: blacklists aggregators to gather continuously information from third parties providing blacklists, real-time verification of traffic going through the VPN using blacklists, real-time detection of IP spoofing by correlating user traffic with HSL darknet traffic and real-time detection of customer hosts infected by a malware.

## 9.2.3. Inria Project Lab

### 9.2.3.1. IPL BetterNet

**Participants:** Isabelle Chrisment [contact], Thibault Cholez, Vassili Rivron, Lakhdar Meftah [University of Lille].

The Inria Project Lab BetterNet (https://project.inria.fr/betternet) has been launched in October 2016. Its goal is to build and deliver a scientific and technical collaborative observatory to measure and improve the Internet service access as perceived by users. We will propose new original user-centered measurement methods, which will associate social sciences to better understand Internet usage and the quality of services and networks. Tools, models and algorithms will be provided to collect data that will be shared and analyzed to offer a valuable service to scientists, stakeholders and civil society.

The Madynes team leads this IPL and in particular Isabelle Chrisment who coordinates the project.

In 2017, the main activities of the project focused on federating Inria's monitoring tools (APISENSE, Fathom, Hostview, ACQUA) and building our open measurement platform for acquiring data.

Lakhdar Meftah, a shared PhD student with the SPIRALS team (Inria/University of Lille) has worked on a privacy preservation scheme using data dissemination that introduces an a priori data anonymization and improves user privacy without compromising the overall quality of the crowdsourced dataset.

### 9.2.3.2. IPL Discovery

**Participant:** Lucas Nussbaum [contact].

To accommodate the ever-increasing demand for Utility Computing (UC) resources, while taking into account both energy and economical issues, the current trend consists in building larger and larger Data Centers in a few strategic locations. Although such an approach enables UC providers to cope with the actual demand while continuing to operate UC resources through centralized software system, it is far from delivering sustainable and efficient UC infrastructures for future needs.

The DISCOVERY initiative aims at exploring a new way of operating Utility Computing (UC) resources by leveraging any facilities available through the Internet in order to deliver widely distributed platforms that can better match the geographical dispersal of users as well as the ever increasing demand. Critical to the emergence of such locality-based UC (also referred as Fog/Edge Computing) platforms is the availability of appropriate operating mechanisms. The main objective of DISCOVERY is to design, implement, demonstrate and promote a new kind of Cloud Operating System (OS) that will enable the management of such a large-scale and widely distributed infrastructure in an unified and friendly manner.

The consortium is composed of experts in the following research areas: large-scale infrastructure management systems, networking and P2P algorithms. Moreover, two key network operators, namely Orange and RENATER, are involved in the project.

By deploying and using a Fog/Edge OS on backbones, our ultimate vision is to enable large parts of the Internet to be hosted and operated by its internal structure itself: a scalable set of resources delivered by any computing facilities forming the Internet, starting from the larger hubs operated by ISPs, governments and academic institutions, to any idle resources that may be provided by end users.

MADYNES contributes to the DISCOVERY IPL on the networking axis. A CIFRE PhD with Orange is expected to start at the beginning of 2018.

# 9.3. European Initiatives

## 9.3.1. FP7 & H2020 Projects

### 9.3.1.1. Fed4Fire+ (2017-2022)

Title: Federation for FIRE Plus

Program: H2020

Duration: January 2017 - December 2021

Coordinator: Interuniversitair Micro-Electronicacentrum Imec VZW

Partners:

Universidad de Malaga

National Technical University of Athens - NTUA

The Provost, Fellows, Foundation Scholars & the other members of board of the College of the Holy & Undivided Trinity of Queen Elizabeth Near Dublin

Ethniko Kentro Erevnas Kai Technologikis Anaptyxis

GEANT LImited

Institut Jozef Stefan

Mandat International Alias Fondation Pour la Cooperation Internationale

Universite Pierre et Marie Curie - Paris 6

Universidad De Cantabria

Fundacio Privada I2CAT, Internet I Innovacio Digital A Catalunya

EURESCOM-European Institute For Research And Strategic Studies in Telecommunications GMBH

Nordunet A/S

Technische Universitaet Berlin

Instytut Chemii Bioorganicznej Polskiej Akademii Nauk

Fraunhofer Gesellschaft zur Foerderung Der Angewandten Forschung E.V.

Universiteit Van Amsterdam

University of Southampton

Martel GMBH

Atos Spain SA

Institut National de Recherche en Informatique et automatique

Inria contact: David Margery (for MADYNES: Lucas Nussbaum)

Fed4FIRE+ is a successor project to Fed4FIRE. In Fed4FIRE+, we more directly integrate Grid'5000 into the wider eco-system of experimental platforms in Europe and beyond using results we developped in Fed4FIRE. We will also provide a generalised proxy mechanisms to allow users with Fed4FIRE identities to interact with services giving access to different testbeds but not designed to support Fed4FIRE identities. Finally, we will work on orchestration of experiments in a federation context. Fed4FIRE+ was prepared in 2016, and has started January 1st, 2017.

## 9.3.2. Collaborations in European Programs, Except FP7 & H2020

### 9.3.2.1. RETINA

Program: Eurosatrs-2

Project acronym: RETINA

Project title: Real-Time support for heterogenous networks in automotive applications

Duration: April 2016 - March 2018

Coordinator: TCN (Time critical networks)

Other partners: TCN (Sweden), Alkit (Sweden), Viktoria (Sweden), TNO (Netherlands), Scuola Superiore Sant'Anna (Italy), Evidence (Italy), University of Lorraine (France)

Abstract: The project will develop integrated software tools to predict, simulate, test and support real-time communication in heterogeneous vehicular networks. The tool set will allow SMEs and larger industry to design, develop and evaluate time-critical applications such as advanced safety systems and autonomous vehicles. This will put high requirements on both in-vehicle infrastructure, as well as vehicle-to-vehicle and vehicle-to infrastructure utilizing the next generation of mobile networks for ITS.

# 9.4. International Initiatives

## 9.4.1. Inria Associate Teams Not Involved in an Inria International Labs

### 9.4.1.1. IoT4D

Title: Internet of Things for Developping countries

International Partner (Institution - Laboratory - Researcher):

> UY (Cameroon) - MASECNeSS - Thomas DJOTIO NDIE

Start year: 2016

See also: https://team.inria.fr/iot4dc/

Our goal is to connect wireless sensors networks (WSN) to the Internet through gateways. WSN should have several accessible gateways (depending on the size and quality of service needed) and gateways should be used by several wireless sensors networks. This is an optimization problem in a peculiar context featuring unreliable communications and equipments that are easily disturbed by environment .

### 9.4.1.2. Masdin

Title: MAnagement of Software-Defined INfrastructure

International Partner (Institution - Laboratory - Researcher):

> University of Luxembourg (Luxembourg) - SnT (Interdisciplinary Centre for Security, Reliability and Trust) - Radu State
>
> Joint publications: [25], [12], [16]

Start year: 2016

See also: https://project.inria.fr/masdin

Networking is deeply evolving with the advent of new paradigms making the network more configurable and more dynamic. In particular, SDN (Software-Defined Network) consists in splitting the control plane and the data plane. A SDN-enabled switch is so only viewed as a specialized device in forwarding data traffic while a logically centralized controller exposes interfaces to services and applications strengthening their coupling. Hence, network is not only a medium of communication but a software component. In the same context, NFV (Network Function Virtualization) promotes the virtualization of all kinds of network functions (router, load-balancer, firewall...) on commodity server, a server in a cloud. These technologies are deeply changing networking principle by allowing a high flexibility in network management. The new features provided by these concepts will thus allow to reinvent the network management in all its areas, especially for network monitoring and provisioning. In addition, even more recent propositions argue for a finer granularity applying the programmability idea of SDN (working at flow level) to packet processing level by promoting the definition of a common language like P4 to reconfigure any switch at low level (vendor independent). The original goal of the associate team is to explore co-jointly this research area through four directions: Monitoring of NFV- and SDN-enabled networks, investigating the integration of data analytics as virtualized functions in virtual networks, security of SDN networks, service chain composition, programming packet processing with P4 and other equivalents. ICN (Information Centric Networking) is also an important topic which is addressed in the team, especially regarding performance (with SDN) and security.

Furthermore, management of blockchain has been set as a new research topic to be focused in the team at the end of 2016. In the scope of network management, our objective is to design monitoring and orchestration methods for blockchain. In particular, we want to assess the relationships and impact between blockchain and network performance. We will have to define proper metrics to catch meaningful data to be analyzed. Moreover, a blockchain technology is by nature without authority (except in the private case), configuration requires thus to enforce some collaboration between nodes.

<p style="text-align:center"><span style="color:red">**ALICE Project-Team**</span></p>

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

### 9.1.1. CPER (2014-2020) 50 k

Sylvain Lefebvre coordinates a work package for the CPER 2014-2020. It involves several members of ALICE as well as laboratories within the Nancy area (Institut Jean Lamour, LRGP, ERPI). Our goal is to consider the interaction between software and material in the additive manufacturing process, with a focus on filament-based printers.

### 9.1.2. PIC (2015-2017) 150 k

The PIC project (Polymères Innovants Composites) is a collaboration between Inria, Institut Jean Lamour and Ateliers Cini, funded by Région Lorraine. The goal is to develop a new additive manufaturing process using filaments of composite materials with applications in mechanical engineering and the medical domain. Our goal in the project is to provide novel ways to deposit the filament that is better suited to the considered materials and improves the quality of the final parts.

## 9.2. National Initiatives

### 9.2.1. EXPLORAGRAM

Inria exploratory project EXPLORAGRAM (in cooperation with MOKAPLAN): We explored new algorithms for computational optimal transport. The project allowed us to hire a post-doc for 18 months (Erica Schwindt). She worked on the semi-discrete algorithm, and its application to the simulation of fluid-structure interactions. The project allowed to strengthen the cooperation with MOKAPLAN. It also allowed us to start exploring new cooperations, with Institut d'Astrophysique de Paris, on early universe reconstruction.

### 9.2.2. ANR MAGA (2016-2020)

We participate to the ANR MAGA (ANR-16-CE40-0014) on the Monge Ampere equation and computational geometry. In this ANR project, we cooperate with Quentin Merigot and other researchers of the MOKAPLAN Inria team on new computational methods for optimal transport.

### 9.2.3. ANR ROOT (2016-2020)

We participate to the Young Researcher ANR ROOT (ANR-16-CE23-0009) on Optimal Transport for computer graphics, with Nicolas Bonneel (CNRS Lyon) as Principal Investigator. In the context of this project, we develop a new symmetric algorithm for semi-discrete optimal transport that optimizes for both the location of the samples and their Lagrange multipliers. An ENS training period will start in Jan. 2018 (Agathe Herrou), hosted in Nancy.

## 9.3. European Initiatives

### 9.3.1. FP7 & H2020 Projects

#### 9.3.1.1. SHAPEFORGE

> Title: ShapeForge: By-Example Synthesis for Fabrication
>
> Program: FP7 (ERC Starting Grant)
>
> Duration: December 2012 - November 2017
>
> Coordinator: Inria

Inria contact: Sylvain Lefebvre

Despite the advances in fabrication technologies such as 3D printing, we still lack the software allowing for anyone to easily manipulate and create useful objects. Not many people possess the required skills and time to create elegant designs that conform to precise technical specifications. 'By–example' shape synthesis methods are promising to address this problem: New shapes are automatically synthesized by assembling parts cutout of examples. The underlying assumption is that if parts are stitched along similar areas, the result will be similar in terms of its low–level representation: Any small spatial neighborhood in the output matches a neighborhood in the input. However, these approaches offer little control over the global organization of the synthesized shapes, which is randomized. The ShapeForge challenge is to automatically produce new objects visually similar to a set of examples, while ensuring that the generated objects can enforce a specific purpose, such as supporting weight distributed in space, affording for seating space or allowing for light to go through. These properties are crucial for someone designing furniture, lamps, containers, stairs and many of the common objects surrounding us. The originality of our approach is to cast a new view on the problem of 'by–example' shape synthesis, formulating it as the joint optimization of 'by–example' objectives, semantic descriptions of the content, as well as structural and fabrication objectives. Throughout the project, we will consider the full creation pipeline, from modeling to the actual fabrication of objects on a 3D printer. We will test our results on printed parts, verifying that they can be fabricated and exhibit the requested structural properties in terms of stability and resistance.

### 9.3.1.2. ICEXL

Title: IceXL: Advanced modeling and slicing software for additive manufacturing

Program: FP7 (ERC Proof of Concept)

Duration: November 2016 - February 2018

Coordinator: Inria

Inria contact: Sylvain Lefebvre

The ICEXL Proof of Concept projects aims at further developing our software IceSL and its industrial potential. We have released several new major features than allowed the software to gain visibility (as shown by a strong increase in downloads towards the end of 2017, 1500+ downloads in November). We have teamed with a selected number of industrial partners to work towards industrial use, and have ongoing discussions regarding technology transfer and licensing.

## 9.4. International Initiatives

### 9.4.1. Inria Associate Teams Not Involved in an Inria International Lab

#### 9.4.1.1. PREPRINT3D

Title: Model Preparation for 3D Printing

International Partner (Institution - Laboratory - Researcher):

> HKU (Hong Kong, China) - Department of Computer Science (CS) - Wenping Wang

Start year: 2017

We seek to develop novel ways to prepare and model objects for 3D printing which better take into account limitations of the fabrication processes as well as real-world properties such as the mechanical strength of the printed object. This is especially important when targeting an audience which is not familiar with the intricacies of industrial design. We target complex, intricate shapes such as models of vegetation and highly detailed meshes, as well as models with thin walls such as architectural models.

### 9.4.2. Inria International Partners

#### 9.4.2.1. Informal International Partners

Jean-Francois Remacle (University of Louvain, Belgium), we cooperate on hexahedral-dominant meshing (visits, students exchange). Our former Ph.D. student Jeanne Pellerin is doing a post-doc in his lab.

# 9.5. International Research Visitors

## 9.5.1. Visits of International Scientists

Li-Yi Wei visited us from 05/04/17 to 18/04/17 to work on the topic of element based topology optimization with Jérémie Dumas, Jonàs Martínez and Sylvain Lefebvre. This work was submitted to SIGGRAPH but not accepted, we plan to resubmit it early 2018.

### 9.5.1.1. Internships

Sylvain Lefebvre supervised Mélanie Siret for a 3 months internship, as well as Jimmy Etienne for a 6 months internship.

## 9.5.2. Visits to International Teams

B. Lévy and Nicolas Ray visited Jean-Francois Remacle (U. Louvain, Belgium). B. Lévy visited Jan Obloj (Oxford, U.K.).

# LARSEN Project-Team

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

### 9.1.1. SATELOR

Title: SATELOR

Program: AME Region Lorraine

Duration: September 2013 - September 2017

Coordinator: Diatelic

PI for Inria: François Charpillet

The Economic Mobilisation Agency in Lorraine has launched a new project Satelor providing it with 2.5 million Euros of funding over 3 years, out of an estimated total of 4.7 million. The leader of the project is Pharmagest-Diatelic. Pharmagest, in Nancy, is the French leader in computer systems for pharmacies, with a 43.5 % share of the market, 9,800 clients and more than 700 employees. Recently, the Pharmagest Group expanded its activities into e-health and the development of telemedicine applications. The Satelor project will accompany the partners of the project in developing services for maintaining safely elderly people with loss of autonomy at home or people with a chronic illness. Larsen team will play an important role for bringing some research results such as:

- developing a low cost environmental sensor for monitoring the daily activities of elderly people at home
- developing a low cost sensor for fall detection
- developing a low cost companion robot able to interact with people and monitoring their activities while detecting emergency situations.
- developing a general toolbox for data-fusion: Bayesian approach.

Publications: [16], [18]

### 9.1.2. Project PsyPhINe: Cogitamus ergo sumus

Title: Cogitamus ergo sumus

Program: PEPS CNRS

Duration: January 2016 - January 2018

Coordinator: MSH Lorraine (USR3261)

Larsen member: Amine Boumaza

This project gathers researchers from the following institutes: InterPsy (EA 4432), APEMAC, EPSaM (EA4360), Archives Henri-Poincaré (UMR7117), Inria Bordeaux Sud-Ouest, Loria (UMR7503). Refer to sec. 7.2.2.2  for the goals of the project.

## 9.2. European Initiatives

### 9.2.1. FP7 & H2020 Projects

#### 9.2.1.1. RESIBOTS

Title: Robots with animal-like resilience

Program: H2020

Type: ERC

Duration: May 2015 - April 2020

Coordinator: Inria

Inria contact: Jean Baptiste Mouret

Despite over 50 years of research in robotics, most existing robots are far from being as resilient as the simplest animals: they are fragile machines that easily stop functioning in difficult conditions. The goal of this proposal is to radically change this situation by providing the algorithmic foundations for low-cost robots that can autonomously recover from unforeseen damages in a few minutes. The current approach to fault tolerance is inherited from safety-critical systems (e.g. spaceships or nuclear plants). It is inappropriate for low-cost autonomous robots because it relies on diagnostic procedures, which require expensive proprioceptive sensors, and contingency plans, which cannot cover all the possible situations that an autonomous robot can encounter. It is here contended that trial-and-error learning algorithms provide an alternate approach that does not require diagnostic, nor pre-defined contingency plans. In this project, we will develop and study a novel family of such learning algorithms that make it possible for autonomous robots to quickly discover compensatory behaviors. We will thus shed a new light on one of the most fundamental questions of robotics: how can a robot be as adaptive as an animal? The techniques developed in this project will substantially increase the lifespan of robots without increasing their cost and open new research avenues for adaptive machines.

### 9.2.1.2. CODYCO

Title: Whole-body Compliant Dynamical Contacts for Humanoids

Programme: FP7

Type: ICT STREP (No. 600716)

Duration: March 2013 - February 2017

Coordinator: IIT

PI for Inria: Serena Ivaldi

The aim of CoDyCo was to improve the current control and cognitive understanding about robust, goal-directed whole-body motion interaction with multiple contacts. CoDyCo went beyond traditional approaches: proposing methodologies for performing coordinated interaction tasks with complex systems; combining planning and compliance to deal with predictable and unpredictable events and contacts; validating theoretical progresses in real-world interaction scenarios. CoDyCo advanced the state-of-the-art in the way robots coordinate physical interaction and physical mobility.

### 9.2.1.3. ANDY

Title: Advancing Anticipatory Behaviors in Dyadic Human-Robot Collaboration

Programme: H2020

Type: ICT RIA (No. 731540)

Duration: January 2017 - December 2020

Coordinator: IIT

PI for Inria: Serena Ivaldi

Recent technological progress permits robots to actively and safely share a common workspace with humans. Europe currently leads the robotic market for safety-certified robots, by enabling robots to react to unintentional contacts. AnDy leverages these technologies and strengthens European leadership by endowing robots with the ability to control physical collaboration through intentional interaction.

To achieve this interaction, AnDy relies on three technological and scientific breakthroughs. First, AnDy will innovate the way of measuring human whole-body motions by developing the wearable AnDySuit, which tracks motions and records forces. Second, AnDy will develop the AnDyModel, which combines ergonomic models with cognitive predictive models of human dynamic behavior

in collaborative tasks, which are learned from data acquired with the AnDySuit. Third, AnDy will propose the AnDyControl, an innovative technology for assisting humans through predictive physical control, based on AnDyModel.

By measuring and modeling human whole-body dynamics, AnDy provides robots with an entirely new level of awareness about human intentions and ergonomy. By incorporating this awareness on-line in the robot's controllers, AnDy paves the way for novel applications of physical human-robot collaboration in manufacturing, health-care, and assisted living.

AnDy will accelerate take-up and deployment in these domains by validating its progress in several realistic scenarios. In the first validation scenario, the robot is an industrial collaborative robot, which tailors its controllers to individual workers to improve ergonomy. In the second scenario, the robot is an assistive exoskeleton which optimizes human comfort by reducing physical stress. In the third validation scenario, the robot is a humanoid, which offers assistance to a human while maintaining the balance of both.

Partners: Italian Institute of Technology (IIT, Italy, coordinator), Josef Stefan Institute (JSI, Slovenia), DLR (Germany), IMK Automotive Gmbh (Germany), XSens (Netherlands), AnyBody Technologies (Denmark)

# 9.3. International Research Visitors

## 9.3.1. Visits of International Scientists

### 9.3.1.1. Internships

- Waldez Azevedo Gomes Junior (Brazil) – from May 2017 to November 2017
- Kazuya Otani (USA, Carnegie Mellon) – from May 2017 to November 2017
- Kapil Sawant (India, BITS Pilani) – from July to December 2017
- Luigi Penco (Italy, La Sapienza University) – from October 2017 to February 2018

<h1 style="text-align:center; color:red">MAGRIT Project-Team</h1>

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

The MAGRIT and the MIMESIS teams have been working for several years on the use of augmented reality for deformable organs and especially on liver surgery. The PhD of Jaime Garcia Guevara started in October 2015 and is funded by the Région Lorraine. It is co-supervised by M.-O. Berger and S. Cotin (MILESIS, Strasbourg). It follows on from our past works and aims at improving the reliability and the robustness of AR-based clinical procedures.

A one year post-doc position was granted by the Region Lorraine and the Université de Lorraine. Cong Yang started this position in November 2016 and ended in October 2017. He developed algorithms for object recognition in large-scale industrial environments (factories, vessels, ...), with the aim to enrich the operator's field of view with digital information and media. The main issues concerned the size of the environment, the nature of the objects (often non textured, highly specular, ...) and the presence of repeated patterns.

## 9.2. National Initiatives

### 9.2.1. *Projet RAPID EVORA*

Participants: M.-O. Berger, V. Gaudillière, G. Simon, C. Yang.
This 3-year project is supported by DGA/DGE and led by the SBS-Interactive company. The objective is to develop a prototype for location and object recognition in large-scale industrial environments (factories, ships...), with the aim to enrich the operator's field of view with digital information and media. The main issues concern the size of the environment, the nature of the objects (often non textured, highly specular...) and the presence of repeated patterns. Use cases will be provided by industrial partners such as DCNS and Areva. A class of officer cadets and professors of the Merchant Marine School will also be associated to judge the pedagogical interest of such a tool. A PhD student, Vincent Gaudillière, has been recruited to work on this project and his contract started in December 2016.

### 9.2.2. *Project funded by GDR ISIS in collaboration with Institut Pascal*

Participant: F. Sur.
Between September 2014 and September 2017, we have been engaged in a collaboration with Institut Pascal funded by GDR ISIS. The aim of this project was the investigation of image processing tools for enhancing the metrological performance of contactless measurement systems in experimental mechanics.

### 9.2.3. *AEN Inria SOFA-InterMedS*

Participants: R. Anxionnat (CHU Nancy), M.-O. Berger, E. Kerrien.
The SOFA-InterMedS large-scale Inria initiative is a research-oriented collaboration across several Inria project-teams, international research groups and clinical partners. Its main objective is to leverage specific competences available in each team to further develop the multidisciplinary field of Medical Simulation research. Our action within the initiative takes place in close collaboration with both the MIMESIS team and the Department of diagnostic and therapeutic interventional neuroradiology of Nancy University Hospital. Two PhD students - R. Trivisonne and J. Guarcia Guevara- are currently co-supervised by the Magrit and the MIMESIS teams.

# 9.3. International Initiatives

## 9.3.1. Inria Associate Teams Not Involved in an Inria International Lab

### 9.3.1.1.  CURATIVE

Title: CompUteR-based simulAtion Tool for mItral Valve rEpair

International Partner (Institution - Laboratory - Researcher):

Harvard University (United States) - Harvard Biorobotics Lab (HBL) - Robert Howe

Start year: 2017

See also: https://team.inria.fr/curative/

The mitral valve of the heart ensures one-way flow of oxygenated blood from the left atrium to the left ventricle. However, many pathologies damage the valve anatomy producing undesired backflow, or regurgitation, decreasing cardiac efficiency and potentially leading to heart failure if left untreated. Such cases could be treated by surgical repair of the valve. However, it is technically difficult and outcomes are highly dependent upon the experience of the surgeon.

One way to facilitate the repair is to simulate the mechanical behavior of the pathological valve with subject-specific data. Our main goal is to provide surgeons with a tool to study solutions of mitral valve repairs. This tool would be a computer-based model that can simulate a potential surgical repair procedure in order to evaluate its success. The surgeons would be able to customize the simulation to a patient and to a technique of valve repair. Our methodology will be to realistically simulate valve closure based on segmentation methods faithful enough to capture subject-specific anatomy and based on a biomechanical model that can accurately model the range of properties exhibited by pathological valves.

During the first year, we worked on three aspects of this project: i) developing a fast image-based mitral valve simulation, ii) extracting the mitral valve chordae from a CT scan (see section New Results) and iii) developing a Cosserat model for catheter robot for heart surgical procedures. The work on fast image-based mitral valve simulation has been accepted to the The International Journal of Medical Robotics and Computer Assisted Surgery [17].

# 9.4. International Research Visitors

## 9.4.1. Visits of International Scientists

Douglas Perrin, a senior researcher at Harvard University (http://people.seas.harvard.edu/~dperrin), visited the MAGRIT team from 05/29/17 to 06/02/17. He gave a talk to the Department 1 in Loria, he helped out with scientific understanding of the mitral valve anatomy and he provided advice to Daryna Panicheva supervision during one week.

Thomas Waite, an undergrad student at Harvard University, visited the MAGRIT team from 06/05/17 to 06/09/17. He gave a talk to the Department 1 in Loria, he worked with Pierre-Frédéric Villard on modeling a heart surgical catheter robot with Cosserat model and started writing a journal paper on this subject.

## 9.4.2. Visits to International Teams

### 9.4.2.1. Research Stays Abroad

Pierre-Frederic Villard spent one month (August 2017) at Uppsala University working on the INVIVE project http://www.it.uu.se/research/scientific_computing/project/rbf/biomech. His work there includes supervising PhD student Igor Tominec, meeting with a physiologist expert in respiration muscles and working on both the mesh and the boundary conditions in the case of a passive diaphragm.

<p style="text-align:center"><span style="color:red">**MULTISPEECH Project-Team**</span></p>

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

### 9.1.1. CPER LCHN

Project acronym: CPER LCHN

Project title: CPER "Langues, Connaissances et Humanités Numériques"

Duration: 2015-2020

Coordinator: Bruno Guillaume (LORIA) & Alain Polguère (ATILF)

Participants: Dominique Fohr, Denis Jouvet, Odile Mella, Yves Laprie

Abstract: The main goal of the project is related to experimental platforms for supporting research activities in the domain of languages, knowledge and numeric humanities engineering.

MULTISPEECH contributes to automatic speech recognition, speech-text alignment and prosody aspects. This year we have also developped a complete system for the transcription of English broadcast TV shows to participate to the MGB challenge.

### 9.1.2. CPER IT2MP

Project acronym: CPER IT2MP

Project title: CPER "Innovation Technologique Modélisation et Médecine Personalisée"

Duration: 2015-2020

Coordinator: Faiez Zannad (Inserm-CHU-UL)

Participants: Romain Serizel, Vishnu Varanasi, Emmanuel Vincent

Abstract: The goal of the project is to develop innovative technologies for health, and tools and strategies for personalized medicine.

MULTISPEECH will investigate acoustic monitoring using an array of microphones.

### 9.1.3. Dynalips

Project title: Control of the movements of the lips in the context of facial animation for an intelligible lipsync.

Duration: February 2017 - January 2018

Coordinator: Slim Ouni

Participants: Valerian Girard, Slim Ouni

Funding: SATT

Abstract: We propose in this project the development of tools of lipsync which from recorded speech will provide realistic mechanisms of animating the lips. These tools will be available to be integrated into existing 3D animation software and existing game engines. One objective is that these lipsync tools fit easily into the production pipeline in the field of 3D animation and video games. The goal of this maturation is to propose a product ready to be exploited in the industry whether by the creation of a start-up or by the distribution of licenses.

## 9.2. National Initiatives

### 9.2.1. E-FRAN METAL

Project acronym: E-FRAN METAL

Project title: Modèles Et Traces au service de l'Apprentissage des Langues

Duration: October 2016 - September 2020

Coordinator: Anne Boyer (LORIA)

Other partners: Interpsy, LISEC, ESPE de Lorraine, D@NTE (Univ. Versailles Saint Quentin), Sailendra SAS, ITOP Education, Rectorat.

Participants: Theo Biasutto-Lervat, Anne Bonneau, Vincent Colotte, Dominique Fohr, Denis Jouvet, Odile Mella, Slim Ouni

Abstract: METAL aims at improving the learning of languages (both written and oral components) through the development of new tools and the analysis of numeric traces associated with students' learning, in order to adapt to the needs and rythm of each learner.

MULTISPEECH is concerned by oral language learning aspects.

### 9.2.2. PIA2 ISITE LUE

Project acronym: ISITE LUE

Project title: Lorraine Université d'Excellence

Duration: starting in 2016

Coordinator: Univ. Lorraine

Participants: Ioannis Douros, Yves Laprie

Abstract: The initiative aims at developing and densifying the initial perimeter of excellence, within the scope of the social and economic challenges, so as to build an original model for a leading global engineering university, with a strong emphasis on technological research and education through research. For this, we have designed LUE as an "engine" for the development of excellence, by stimulating an original dialogue between knowledge fields.

MULTISPEECH is mainly concerned with challenge number 6: "Knowledge engineering", i.e., engineering applied to the field of knowledge and language, which represent our immaterial wealth while being a critical factor for the consistency of future choices. In 2016, this project has funded a new PhD thesis.

### 9.2.3. ANR ContNomina

Project acronym: ContNomina

Project title: Exploitation of context for proper names recognition in diachronic audio documents

Duration: February 2013 - March 2017

Coordinator: Irina Illina

Other partners: LIA, Synalp

Participants: Dominique Fohr, Irina Illina, Denis Jouvet, Odile Mella, Imran Sheikh

Abstract: The ContNomina project was focus on the problem of proper names in automatic audio processing systems by exploiting in the most efficient way the context of the processed documents. To do this, the project has addressed the statistical modeling of contexts and of relationships between contexts and proper names; the contextualization of the recognition module (through the dynamic adjustment of the lexicon and of the language model in order to make them more accurate and certainly more relevant in terms of lexical coverage, particularly with respect to proper names); and the detection of proper names (on the one hand, in text documents for building lists of proper names, and on the other hand, in the output of the recognition system to identify spoken proper names in the audio/video data).

MULTISPEECH contributes to speech recognition and proper names handling (prediction, introduction in models, ...)

### 9.2.4. ANR DYCI2

Project acronym: DYCI2 (http://repmus.ircam.fr/dyci2/)

Project title: Creative Dynamics of Improvised Interaction

Duration: March 2015 - February 2018

Coordinator: Ircam (Paris)

Other partners: Inria (Nancy), University of La Rochelle

Participants: Ken Deguernel, Nathan Libermann, Emmanuel Vincent

Abstract: The goal of this project is to design a music improvisation system which will be able to listen to the other musicians, improvise in their style, and modify its improvisation according to their feedback in real time.

MULTISPEECH is responsible for designing a system able to improvise on multiple musical dimensions (melody, harmony) across multiple time scales.

### 9.2.5. ANR JCJC KAMoulox

Project acronym: KAMoulox

Project title: Kernel additive modelling for the unmixing of large audio archives

Duration: January 2016 - January 2019

Coordinator: Antoine Liutkus

Participants: Mathieu Fontaine, Antoine Liutkus

Abstract: The objective is to develop the theoretical and applied tools required to embed audio denoising and separation tools in web-based audio archives. The applicative scenario is to deal with large audio archives, and more precisely with the notorious "Archives du CNRS — Musée de l'homme", gathering about 50,000 recordings dating back to the early 1900s.

### 9.2.6. ANR ArtSpeech

Project acronym: ArtSpeech

Project title: Synthèse articulatoire phonétique

Duration: October 2015 - March 2019

Coordinator: Yves Laprie

Other partners: Gipsa-Lab (Grenoble), IADI (Nancy), LPP (Paris)

Participants: Ioannis Douros, Benjamin Elie, Yves Laprie, Anastasiia Tsukanova

Abstract: The objective is to synthesize speech from text via the numerical simulation of the human speech production processes, i.e. the articulatory, aerodynamic and acoustic aspects. Corpus based approaches have taken a hegemonic place in text to speech synthesis. They exploit very good acoustic quality speech databases while covering a high number of expressions and of phonetic contexts. This is sufficient to produce intelligible speech. However, these approaches face almost insurmountable obstacles as soon as parameters intimately related to the physical process of speech production have to be modified. On the contrary, an approach which rests on the simulation of the physical speech production process makes explicitly use of source parameters, anatomy and geometry of the vocal tract, and of a temporal supervision strategy. It thus offers direct control on the nature of the synthetic speech.

Acquisition and processing of cineMRI, new developments of acoustic simulations concercing the production of fricatives and trills, and first workds in the implementation of coarticulation in articulatory synthesis are the main activities of this year.

### 9.2.7. ANR VOCADOM

Project acronym: VOCADOM (http://vocadom.imag.fr/)

Project title: Robust voice command adapted to the user and to the context for AAL

Duration: January 2017 - December 2020

Coordinator: CNRS - LIG (Grenoble)

Other partners: Inria (Nancy), Univ. Lyon 2 - GREPS, THEORIS (Paris)

Participants: Dominique Fohr, Sunit Sivasankaran, Emmanuel Vincent

Abstract: The goal of this project is to design a robust voice control system for smart home applications. We are responsible for the speech enhancement and robust automatic speech recognition bricks.

MULTISPEECH is responsible for wake-up word detection, overlapping speech separation, and speaker recognition.

### 9.2.8. FUI VoiceHome

Project acronym: VoiceHome

Duration: February 2015 - July 2017

Coordinator: VoiceBox Tachnologies France

Other partners: Orange, Delta Dore, Technicolor Connected Home, eSoftThings, Inria (Nancy), IRISA, LOUSTIC

Participants: Irina Illina, Karan Nathwani, Emmanuel Vincent

Abstract: The goal of this project was to design a robust voice control system for smart home and multimedia applications. We were responsible for the robust automatic speech recognition brick.

MULTISPEECH was responsible for robust automatic speech recognition by means of speech enhancement and uncertainty propagation.

### 9.2.9. MODALISA

Project acronym: MODALISA

Project title: Multimodality during Language Acquisition: Interaction between Speech Signal and gestures

Duration: January 2017 - December 2017

Coordinator: Christelle Dodane (Praxiling, UMR 5267, Montpellier)

Other partners: Slim Ouni

Participants: Slim Ouni

Funding: CNRS DEFI Instrumentation aux limites

Abstract: The objective of this project was to setup a multimodal platform allowing simultaneous visualization of gestural (motion capture system) and prosodic data during speech and more specifically during language acquisition.

Les contributions de MULTISPEECH concernent l'acquisition et le traitement des données multimodales grâce à la plateforme multimodale MultiMod.

## 9.3. European Initiatives

### 9.3.1. Collaborations in European Programs, Except FP7 & H2020

#### 9.3.1.1. AMIS

Program: CHIST-ERA

Project acronym: AMIS

Project title: Access Multilingual Information opinionS

Duration: Dec 2015- Nov 2018

Coordinator: Kamel Smaïli

Other partners: University of Avignon, University of Science and Technology Krakow, University of DEUSTO (Bilbao)

Participants: Dominique Fohr, Denis Jouvet, Odile Mella

Abstract: The idea of the project is to develop a multilingual help system of understanding without any human being intervention. What the project would like to do, is to help people understanding broadcasting news, presented in a foreign language and to compare it to the corresponding one available in the mother tongue of the user.

MULTISPEECH contributions concern mainly the speech recognition in French, English and Arabic videos.

### 9.3.2. Collaborations with Major European Organizations

Jon Barker: University of Sheffield (UK)

Robust speech recognition [22], [10], [9], [70]

## 9.4. International Initiatives

### 9.4.1. Inria International Partners

#### 9.4.1.1. Informal International Partners

Shinji Watanabe, Johns Hopkins University (USA)

Robust speech recognition [22], [10], [9], [70]

### 9.4.2. Participation in Other International Programs

#### 9.4.2.1. PHC UTIQUE - Arabic speech synthesis

PHC UTIQUE - Arabic speech synthesis, with ENIT (École Nationale d'Ingénieurs de Tunis, Tunisia)

Duration: 2015 - 2018.

Coordinators: Vincent Colotte (France) and Zied LACHIRI (Tunisia).

Participants: Vincent Colotte, Amal Houidhek, Denis Jouvet

Abstract: Modeling of a speech synthesis system for the Arabic language. This includes the use of an Arabic speech corpus, the selection of linguistic features relevant to an Arabic speech synthesis, as well as improving the quality of the speech signal generated by the system (prosodic and acoustic features).

MULTISPEECH co-supervises PhD students.

#### 9.4.2.2. FIRAH - La famille face au handicap

Program: FIRAH, International Foundation of Applied Disability Research

Project title: La famille face au handicap : la gestion du stress parental des parents d'enfants souffrant du syndrome de Dravet

Duration: Jan 2017- Dec 2019

Coordinator: T. Leonova, University of Lorraine (Perseus)

Other partners: MHS-USR 3261 CNRS, Université de Lorraine, Associations Alliance Syndrome de Dravet (France) and Alliance Syndrome de Dravet (Suisse), Hopital de Hautepierre - Strasbourg University (France), Hopital Necker enfants malades - Paris Descartes University - INSERM U1129, Hôpital Robert Debré - Paris Diderot University- INSERM U1141, Hôpitaux Universitaires de Genève - Université de Genève (Suisse), Université catholique du Sacré Cœur - Rome (Italie), Quebec University (Canada), McMaster Children's Hospital - McMaster University - Hamilton (Canada), MIA518-AgroParisTech/INRA.

Participant: Agnès Piquard-Kipffer

Abstract: the aims of the project are, in a first step, to explore parental stress with Chidren with Dravet syndrom which combine infant epilepsy and autism and in a second step to create a training programm for professionnals of Education [68], [69]

In this project, MULTISPEECH is involved in finding the best ways to maximize the communication efficiency between the children and their families, using the methodology or the tools created by the Handicom project.

## 9.5. International Research Visitors

### 9.5.1. Visits of International Scientists

Ziteng Wang

Date: Sep 2016 – Sep 2017

Institution: Institute of Acoustics, Chinese Academy of Sciences (China)

Vishnuvardhan Varanasi

Date: Feb – Aug 2017

Institution: Indian Institute of Science, Kanpur (India)

Md Sahidullah

Date: Aug – Oct 2017

Institution: University of Eastern Finland (Finland)

### 9.5.2. Visits to International Teams

#### 9.5.2.1. Research Stays Abroad

Antoine Liutkus was invited by Kazuyoshi Yoshii (RIKEN, Kyoto University) to work on multichannel extensions to his tensor-factorization methods, that would also allow for much easier inference. This led to a joint publication [47] about the resulting method.

<p align="center" style="color:red"><b>ORPAILLEUR Project-Team</b></p>

# 8. Partnerships and Cooperations

## 8.1. Regional Initiatives

### 8.1.1. *Hydreos*

**Participant:**  Jean-François Mari.

Hydreos is a state organization -a so-called "Pôle de compétitivité"– aimed at evaluating the delivering and the quality of water (http://www.hydreos.fr/fr). Actually, data about water resources rely on many agronomic variables, including land use successions. The data to be analyzed are obtained by surveys or by satellite images and describe the land use at the level of the agricultural parcel. Then there is a search for detecting changes in land use and for correlating these changes to groundwater quality. Accordingly, one main challenge in our participation in Hydreos is to process and analyze space-time data for reaching a better understanding of the changes in the organization of a territory. The systems ARPEnTAge and CarottAge are used in this context, especially by agronomists of INRA (ASTER Mirecourt http://www6.nancy.inra.fr/sad-aster).

### 8.1.2. *The Smart Knowledge Discovery Project*

**Participants:**  Jérémie Nevin, Amedeo Napoli, Chedy Raïssi.

The SKD project for "Smart Knowledge Discovery" aims at analyzing complex industrial data for troubleshooting and decision making, and is funded by "Grand Est Region". We are working with the Vize company –which is based in Nancy and specialized in visualization-based data mining– on exploratory knowledge discovery. The data which are under study are provided by the Arcelor-Mittal Steel Company and are related to the monitoring of rolling mills. Data are complex time series and the problem can be set as follows: problem statement, data access and preparation, design of adapted knowledge discovery methods based on symbolic and numerical methods, interaction with analysts, tests and validation. For the Orpailleur team, one main objective of SKD is to combine sequence mining and visualization tools for recognizing and then preventing the occurrences of defects in the outputs of the rolling mills.

## 8.2. National Initiatives

### 8.2.1. *ANR*

#### 8.2.1.1. *Elker (2017–2020)*

**Participants:**  Miguel Couceiro, Esther Catherine Galbrun, Amedeo Napoli, Chedy Raïssi.

The objectives of the new ELKER ANR Research Project is to study, formalize and implement the search for link keys in RDF data. Link keys generalize database keys in two independent directions, i.e. they deal with RDF data and they apply across two datasets. The goal of ELKER is to study the automatic discovery of link keys and reasoning with link keys, especially in taking an FCA point of view. One main idea is to rely on the competencies of Orpailleur in FCA for solving the problem using FCA and pattern structures algorithms, especially those related to the discovery of functional dependencies. This project involves the EPI Orpailleur at Inria Nancy Grand Est, the EPI MOEX at Inria Rhône Alpes, and LIASD at Université Paris 8.

#### 8.2.1.2. *ISTEX (2014–2017)*

**Participant:**  Yannick Toussaint.

ISTEX is a so-called "Initiative d'excellence" managed by CNRS and DIST ("Direction de l'Information Scientifique et Technique"). ISTEX aims at providing the research and teaching community an on-line access to scientific publications in all domains (http://www.istex.fr/istex-excellence-initiative-of-scientific-and-technical-information/). In this way, ISTEX requires a massive acquisition of documents such as journals, proceedings, corpora, and databases. The Orpailleur team was especially involved in the development of facilities for querying full-text documentation, analyzing content and extracting information. The project was carried out in collaboration with the ATILF laboratory and the INIST Institute (both located in Nancy).

### 8.2.1.3. PractiKPharma (2016–2020)

**Participants:**  Adrien Coulet, Joël Legrand, Pierre Monnin, Amedeo Napoli, Malika Smaïl-Tabbone, Yannick Toussaint.

PractiKPharma for "Practice-based evidences for actioning Knowledge in Pharmacogenomics" is an ANR research project (http://practikpharma.loria.fr/) about the validation of domain knowledge in pharmacogenomics. Pharmacogenomics is interested in understanding how genomic variations related to patients have an impact on drug responses. Most of the available knowledge in pharmacogenomics (state of the art) lies in biomedical literature, with various levels of validation. An originality of PractiKPharma is to use Electronic Health Records (EHRs) to constitute cohorts of patients. These cohorts are then mined for extracting potential pharmacogenomics patterns to be then validated w.r.t. literature knowledge for becoming actionable knowledge units. More precisely, firstly we should extract pharmacogenomic patterns from the literature and secondly we should confirm or moderate the interpretation and validation of these units by mining EHRs. Comparing knowledge patterns extracted from the literature with facts extracted from EHRs is a complex task depending on the EHR language –literature is in English whereas EHRs are in French– and on knowledge level, as EHRs represent observations at the patient level whereas literature is related to sets of patients. The PractiKPharma involves three other laboratories, namely LIRMM in Montpellier, SSPIM in St-Etienne and CRC in Paris.

## 8.2.2. CNRS PEPS and Mastodons projects

### 8.2.2.1. Mastodons Projects: from HyQual to HyQualiBio (2016–2018)

**Participants:**  Miguel Couceiro, Esther Catherine Galbrun, Tatiana Makhalova, Amedeo Napoli, Chedy Raïssi, Justine Reynaud.

The HyQual project was proposed in 2016 in response to the Mastodons CNRS Call about data quality in data mining (see http://www.cnrs.fr/mi/spip.php?article819&lang=fr). This project is interested in the mining of nutritional data for discovering predictive biomarkers of diabetes and metabolic syndrome in elder populations. The considered data mining methods are hybrid, and they combine symbolic and numerical methods for mining complex and noisy metabolic data [80]. Regarding the mining process, we are interested in the quality of the data at hand and in the discovered patterns. In particular, we check the incompleteness of the data, the quality of the extracted rules and the possible existence of redescriptions.

Initially, the project involved researchers from the EPI Orpailleur, with researchers from LIRIS Lyon, ICube Strasbourg, and INRA Clermont-Ferrand. This year, we were merged with another Mastodons project, namely QualiBioConsensus, about the "ranking of biological data using consensus ranking techniques". The joint Mastodons project is now called "HyQualiBio". The topics of interest for the participants are the mining of complex biological data, rankings and ties in rankings, and the search of dependencies in the web of data.

### 8.2.2.2. PEPS Decade

**Participants:**  Miguel Couceiro, Esther Catherine Galbrun, Nyoman Juniarta, Amedeo Napoli, Justine Reynaud, Chedy Raïssi.

Decade stands for "Découverte et exploitation des connaissances pour l'aide à la décision en chimie thérapeutique". The objective of the CNRS PEPS Decade project is to study the basis of knowledge system for analyzing the so-called PAINS ("Pan Assay Interference Compounds") in chemistry. The system should rely on the knowledge possibly discovered in the data and domain knowledge and expertise. The members of the projects are interested in data mining techniques guided by constraints and preferences, "instant data mining", subgroup discovery and exceptional model mining. All these topics were already of interest in the PEPS Prefute (2015-2016) which was about interaction and iteration in the knowledge discovery process.

The members of the Decade project are from Greyc Caen, LIFO Orléans LIRIS Lyon, Université de Tours-Blois, EPI Lacodam in Rennes and EPI Orpailleur (in association with chemists based in Caen and Orléans)

# 8.3. European Initiatives

## 8.3.1. FP7 & H2020 Projects

### 8.3.1.1. CrossCult (H2020 Project, 2016-2020)
**Participants:**  Miguel Couceiro, Nyoman Juniarta, Amedeo Napoli, Chedy Raïssi.

CrossCult (http://www.crosscult.eu/) aims to make reflective history a reality in the European cultural context, by enabling the re-interpretation of European (hi)stories through cross-border interconnections among cultural digital resources, citizen viewpoints and physical venues. The project has two main goals. The first goal is to lower cultural EU barriers and create unique cross-border perspectives, by connecting existing digital historical resources and by creating new ones through the participation of the public. The second goal is to provide long-lasting experiences of social learning and entertainment that will help for achieving a better understanding and re-interpretation of European history. To achieve these goals, CrossCult will use cutting-edge technology to connect existing digital cultural assets and to combine them with interactive experiences that all together are intended to increase retention, stimulate reflection and help European citizens appreciate their past and present in a holistic manner. CrossCult will be implemented on four real-world flagship pilots involving a total of 8 sites across Europe.

The role of the Orpailleur Team (in conjunction with the LORIA Kiwi Team) is to work on knowledge discovery and recommendation. The focus is on the mining of visitor trajectories for analysis purposes, and on the definition of a visitor profile in connection with domain knowledge for recommendation.

The numerous partners of the Orpailleur team in the CrossCult project are: Luxembourg Institute for Science and Technology and Centre Virtuel de la Connaissance sur l'Europe (Luxembourg, leader of the project), University College London (England), University of Malta (Malta), University of Peloponnese and Technological Educational Institute of Athens (Greece), Università degli Studi di Padova (Italy), University of Vigo (Spain), National Gallery (London, England), and GVAM Guìas Interactivas (Spain).

# 8.4. International Initiatives

## 8.4.1. Inria Associate Teams Not Involved in an Inria International Lab

### 8.4.1.1. Snowball

Title: Discovering knowledge on drug response variablity by mining electronic health records

International Partner (Institution - Laboratory - Researcher):

Stanford (United States) - Department of Medicine, Stanford Center for Biomedical Informatics Research (BMIR) - Nigam Shah

Start year: 2017

See also: http://snowball.loria.fr/

Snowball (2017-2019) is an Inria Associate Team and the continuation of the preceding Associate Team called Snowflake (2014-2016). The objective of Snowball is to study drug response variability through the lens of Electronic Health Records (EHRs) data. This is motivated by the fact that many factors, genetic as well as environmental, imply different responses from people to the same drug. The mining of EHRs can bring substantial elements for understanding and explaining drug response variability.

Accordingly the objectives of Snowball are to identify in EHR repositories groups of patients which are responding differently to similar treatments, and then to characterize these groups and predict patient drug sensitivity. These objectives are complementary to those of the PractiKPharma ANR project. Moreover, it should be noticed that Adrien Coulet has started a one-year sabbatical stay in the lab of Nigam Shah at Stanford University since September 2017.

### 8.4.2. Participation in International Programs

*8.4.2.1. A stay at NASA Frontier Development Lab*

In July 2017, Chedy Raïssi visited NASA Ames and SETI Institute as part of the Frontier Development Lab. He worked on mentoring teams and developing meaningful research opportunities, as well as supporting the work of the planetary defense community and showing the potential of this kind of applied research methodology to deliver breakthrough of significant value.

Delay-Doppler radar imaging is a powerful technique to characterize the trajectories, shapes, and spin states of near-Earth asteroids and has yielded detailed models of dozens of objects. Since the 1990s, delay-Doppler data has been analyzed using the SHAPE software developed originally by Steven J. Ostro. SHAPE performs sequential single-parameter fitting, and requires considerable computation runtime and human intervention. Recently, multiple-parameter fitting algorithms have been shown to more efficiently invert delay-Doppler datasets thus decreasing runtime while improving accuracy. However, reconstructing asteroid shapes and spins from delay-Doppler data is, like many inverse problems, computationally intensive and requires extensive human oversight of the shape modeling process.

Thus we have explored two new techniques to better automate delay-Doppler shape modeling: Bayesian optimization and deep generative models. Firstly we have implemented a Bayesian optimization routine that uses SHAPE to autonomously search the space of spin-state parameters. Bayesian optimization yielded similar spin state constraints with computer runtime reduced by a factor of 3. Secondly, the shape modeling process could be further accelerated using a deep *"generative model"* to replace or complete iterative fitting. Accordingly, we have implemented and trained a deep generative model based on different architectures of deep convolutional networks. Results are currently under analysis and future publications are in preparation.

*8.4.2.2. LEA STRUCO*

**Participant:** Jean-Sébastien Sereni.

LEA STRUCO is an "Associated International Laboratory" of CNRS between IÚUK, Prague, and LIAFA, Paris. It focuses on high-level study of fundamental combinatorial objects, with a particular emphasis on comprehending and disseminating the state-of-the-art theories and techniques developed. The obtained insights shall be applied to obtain new results on existing problems as well as to identify directions and questions for future work. Jean-Sébastien Sereni is the founder and previous director of LEA STRUCO, which was initiated when Jean-Sébastien was a member of LIAFA, and he is now a member of its scientific committee.

*8.4.2.3. Research Collaboration with HSE Moscow*

**Participants:** Miguel Couceiro, Adrien Coulet, Tatiana Makhalova, Amedeo Napoli, Chedy Raïssi, Justine Reynaud.

An on-going collaboration involves the Orpailleur team and Sergei O. Kuznetsov at Higher School of Economics in Moscow (HSE). Amedeo Napoli visited HSE laboratory several times while Sergei O. Kuznetsov visits Inria Nancy Grand Est every year. The collaboration is materialized by the joint supervision of students (such as the thesis of Aleksey Buzmakov defended in 2015 and the on-going thesis of Tatiana Makhalova), and the the organization of scientific events, as the workshop FCA4AI with five editions between 2012 and 2016 (see http://www.fca4ai.hse.ru).

This year, we participated in the organization of two main events: a special session about Knowledge Discovery and Formal Concept Analysis at the ISMIS Conference in Warsaw (Poland) in June 2017 (http://ismis2017. ii.pw.edu.pl/s_kd_fca.php), and the chairing of the track "General Topics of Data Analysis" at the AIST Conference in Moscow in July 2017 (6th International Conference on Analysis of Images, Social Networks, and Texts http://aistconf.org/). Finally a next edition of the seventh edition of the FCA4AI workshop is planned in July 2018 at the ECAI-IJCAI Conference to be held in Stockholm Sweden.

## SEMAGRAMME Project-Team

# 7. Partnerships and Cooperations

## 7.1. Regional Initiatives

### 7.1.1. SLAM

**Participants:** Maxime Amblard [coordinator], Philippe de Groote, Sylvain Pogodalla.

Schizophrenia is well known among mental illnesses for the strength of the thought disorders it involves, and for their widespread and spectacular manifestations: from deviant social behavior to delusion, not to speak about affective and sensitive distortions. The SLAM project aims at exploring the specific manifestation of disorders in conversational speech. This is an interdisciplinary research, both empirical and theoretical, from several domains, namely psychology, philosophy, linguistic, and computer science.

After having built building a corpus of pathological uses of language [9], the first transcriptions of pathological interviews have been analyzed [8]. A processing chain was implemented for disfluences and part-of-speech. We have focused on implementing the treatment of lexicographical issues, and proposed an interface for SDRT-annotations. We also started to collect new data with new patients at the Centre Médical d'Aix-en-Provence, and to re-implement the SLAMtk tool.

The SLAM project was supported by the MSH–Lorraine, USR 3261, the region Grand Est, and the Université de Lorraine. We have organized the fourth workshop (In)Coherence of Discourse which gathered linguists, psychologists, and computer scientists in March 2017.

## 7.2. National Initiatives

### 7.2.1. DGLFLF (Délégation générale à la langue française et aux langues de France)

#### 7.2.1.1. PLURAL

**Participants:** Bruno Guillaume [coordinator], Nicolas Lefebvre.

The objective of the PLURAL project is to build linguistic resources with GWAPs (Game With A Purpose) for poorly endowed languages. Unlike other languages, poorly endowed languages lack of freely available raw corpora. The goal of the PLURAL project is to provide a web inferface to gather corpora in poorly endowed languages of France. First target languages are Alsacian and Guadeloupean creole. The main difficulty is to take into account orthographic diversity and regional diversity for these languages.

Partners of the PLURAL projet are: Université Paris-Sorbonne (Karën Fort, Alice Millour, André Thibault) and Université de Strasbourg (Delphine Bernhard).

Nicolas Lefebvre is engineer in the PLURAL project from October 2017 to March 2018.

## 7.3. International Initiatives

### 7.3.1. Inria International Partners

#### 7.3.1.1. Informal International Partners

Maxime Amblard have started discussing with the Centre for Linguistic Theory and Studies in Probability (CLASP, University of Gothenburg, Sweden), about computational treatments of dialogues of patients with schizophrenia. We have common issues about the management such corpora and about the modeling of such interactions. As for now, ongoing discussions have not yet been turned into a formal project.

## 7.4. International Research Visitors

### 7.4.1. Visits to International Teams

#### 7.4.1.1. Research Stays Abroad

Timothée Bernard visited New York University, USA, from September 1st to December 15th, 2017.